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RECORDS

OF THE

SURVEY OF INDIA

Volume III

1911-12

PREPARED UNDER THE DIRECTION OF

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CONTENTS.

PART I.—TOPOGRAPHICAL SURVEY.

REPORTS FROM THE NORTHERN CIRCLE.

REPORTS FROM THE SOUTHERN CIRCLE.

REPORTS FROM THE EASTERN CIRCLE.

PART II.—GEODETIC SURVEY.

PART III.—TRIANGULATION.

PART IV.—TIDAL OPERATIONS.

PART V.—LEVELLING.

PART VI.—MAGNETIC SURVEY.

PART VII.—REPRODUCING OFFICES.

ILLUSTRATIONS.

MAPS

(at end of Volume).

APPENDICES.

RECORDS OF

THE SURVEY OF INDIA

PART I.—TOPOGRAPHICAL SURVEY.

NORTHERN CIRCLE.

(*Vide* Index Maps 1 and 4.)

The circle remained under the superintendence of Colonel W. J. Bythell, R.E., up to the 2nd of April, and after that date, was under the superintendence of Major C. H. D. Ryder, D.S.O., R.E.

The circle consisted of Nos. 1, 2, 3 and 4 field parties.

During the past field season 23,852 square miles were surveyed, detail as follows:—

	Sq. Miles.
No. 1 Party, Kashmīr, Original Survey, 1-inch	4,489
No. 2 „ Punjab, Original and Revision Survey, 1-inch and 1½-inch .	7,369
No. 3 „ United Provinces, Revision Survey, 1-inch	6,187
No. 4 „ „ „ Original and Supplementary Survey, 1-inch .	5,807

The Riverain Detachment carried out 332·95 linear miles of main, and 1911·26 miles of minor traverse.

A special detachment was sent to carry out a revision survey of Delhi and the vicinity on the 4-inch scale for the Delhi Town-planning Committee (*vide* p. 13).

No. 1 PARTY (KASHMĪR).

BY MAJOR C. H. D. RYDER, D.S.O., R.E.

PERSONNEL.

Imperial Officers.

Major C. H. D. Ryder, D.S.O., R.E., in charge from 1st October 1911 to 28th March 1912.

Major F. W. Pirrie, I.A., in charge from 29th March 1912.

Lieutenant K. Mason, R.E.

Provincial Officers.

Mr. H. H. B. Hanby.

Mr. E. B. West (from 5th June 1912).

Mr. D. K. Rennick.

Mr. R. C. Hanson.

Mr. W. J. B. Miller.

The head-quarters of the party remained at Srinagar (Kashmīr) throughout the survey year.

The survey of the Kashmīr valley proper was continued on the scale of 1 inch to 1 mile and completed and the work extended northwards on the same scale at the request of the Kashmīr Durbar into the Kishenganga valley as far as the watersheds to the north and east.

The winter of 1911-12, though mild in the Kashmīr valley, was a late one and the snow in the higher hills made work very

Upper Subordinate Service.

Mr. Sher Jang, K.B.
Mr. Natha Singh, R.S.
Mr. Lal Singh, R.B.
Mr. Paras Ram (promoted to U.S.S. from 1st July 1912).
Mr. Jamna Pershad (promoted to U.S.S. from 1st July 1912).

Lower Subordinate Service.

Surveyors, etc. 35

difficult in April and May, and in the Kishenganga valley impossible till the beginning of June. For these reasons the strength of the party had to be increased in order to complete the programme, as it involved triangulating and surveying in detail the Kishenganga valley in four and a half months, which work was successfully carried out.

Operations in the field were commenced in April 1912, and continued till the middle of October 1912.

The health of the party has been good and there has not been much sickness, owing to the extra precautions taken when men had to work under severe climatic conditions.

There have been a few but no fatal cases of small-pox among members of the party.

Topography.—The area surveyed on the scale of 1 inch to 1 mile was 4,489 square miles. The party was divided at the commencement of the summer field season into 2 camps, and later on, into 4 camps, under Messrs. Hanby, West, Rennick and Hanson, and the number of detail surveyors varied from 7 in April, to 31 in September. The following sheets were surveyed in the field by the middle of October 1912 :—

The whole of—	Parts of—
$43\frac{F}{14}$	$43\frac{F}{6,\ 9,\ 10,\ 13}$
$43\frac{J}{2,\ 5,\ 6,\ 10,\ 14,\ 15}$	$43\frac{I}{4,\ 8,\ 12}$
$43\frac{K}{14}$	$43\frac{J}{1,\ 9,\ 13}$
$43\frac{N}{3,\ 8}$	$43\frac{K}{5,\ 6,\ 10,\ 15}$
$43\frac{O}{2,\ 6}$	$43\frac{N}{1,\ 2,\ 6,\ 7,\ 11,\ 12}$
	$43\frac{O}{5,\ 7,\ 10}$

The sheets surveyed in part are up to the limit of the Kishenganga northern and eastern watersheds. Wherever the watersheds are the limit of the area to be surveyed on the 1-inch scale, half a mile beyond has been surveyed, to obtain a satisfactory junction with the smaller scale surveys, when the degree sheets on the $\frac{1}{4}$-inch scale are compiled. The cost-rate was as follows :-- 1-inch detail area, 4,489 square miles at Rs. 16·2 per square mile. An area of 866 square miles was surveyed in detail by surveyor Surjan Singh from the beginning of June to the middle of September on the scale of $\frac{1}{2}$ inch to 1 mile on and in the vicinity of the Siāchen glacier in Baltistan when attached to the Bullock Workman expedition. The actual pay of surveyor Surjan Singh and his servant and ordinary travelling allowance were met by the Survey of India and the remaining expenses were paid by Mrs. Bullock Workman, it being understood that the map would be put at the disposal of the Survey of India on the return of the expedition. The cost-rate was as follows :—$\frac{1}{2}$-inch detail area. 866 square miles at Rs. 1·1, (share paid by the Survey of India).

Triangulation.—During the previous winter triangulation was carried out in the field in the lower ground south of the Pir Panjal range in parts of Jammu and Poonch States, (the remainder of the party being employed in map drawing in Srinagar).

Of the sheets surveyed in detail on the 1-inch scale, only about 8 sheets had been triangulated in advance at the commencement of the field season.

At the close of the field season the area triangulated in advance for future detail surveys on the 1-inch scale was 5,916 square miles, about 23 sheets in area.

The cost-rate of triangulation was as follows:—

Triangulation for 1-inch surveys, area 8,421 square miles, at Rs. 4·3 per square mile.

Recess duties.—The area of fair mapping sent for publication was 3,702 square miles and consisted of 15 1-inch sheets, *viz.*:—

$$43\ \frac{F}{11,\ 12,\ 15,\ 16}$$

$$43\ \frac{J}{3,\ 4,\ 7,\ 8,\ 11,\ 12,\ 16}$$

$$43\ \frac{K}{9,\ 13}$$

$$43\ \frac{N}{4}$$

$$43\ \frac{O}{1}$$

The cost of fair mapping was as follows:—

15 1-inch sheets, area 3,702 square miles at Rs. 7·1 per square mile.

The total cost of the party was Rs. 1,36,287.

No. 2 PARTY (PUNJAB).

BY MAJOR E. A. TANDY, R.E.

The season's work lay in the plains of the Punjab, comprising all the sheets in 44I and 44M, except $\frac{I}{1\ \&\ 5}$ and $\frac{M}{13}$.

Sheets $\frac{I}{1\ \&\ 5}$ were omitted because the country is being altered by new irrigation, and sheet $\frac{M}{13}$ because it included some difficult Siwālik work. This latter sheet will be taken up in the coming season, but the former will have to await the development of the new irrigation.

The area surveyed includes all Amritsar District and Kapurthala State, and parts of districts Sialkot, Gujranwala, Lahore, Ferozepore, Jullundur, Hoshiārpur and Gurdāspur.

The party left recess quarters Mussoorie on the 27th October and reopened on the 1st May. The field head-quarters were at Lahore throughout the field season.

PERSONNEL.

Imperial Officers.

Major F. W. Pirrie, I.A., in charge up to 24th March.
Major E. A. Tandy, R.E., in charge from 26th June.

Provincial Officers.

Mr. F. B. Powell, attached to the Northern Circle Drawing Office during the field season.
Mr. J. A. Freeman, in charge from 25th March to 25th June.
Mr. E. B. West, from 1st March to 4th June.
Subedar Kanak Singh.
Mr. R. E. Saubolle.
Mr. E. C. O'Sullivan.
Mr. J. McCraken, absent on Delhi Survey from 29th March.
Mr. J. A. Calvert, from 29th May.

Upper Subordinate Service.

Mr. Mahindar Singh, up to 31st October.

Lower Subordinate Service.

34 Surveyors.
2 New Soldier Surveyors.
5 Draftsmen.
2 Clerks.
1 Store-keeper.
5 Other draftsmen.

The health of the party was very good throughout the year.

Topography.—No. 2 (late 15) Party surveyed an area of 7,369 square miles in Amritsar, Sialkot, Gujranwala, Lahore, Ferozepore, Jullundur, Hoshiārpur and Gurdāspur districts and Kapurthala State, about three-quarters of this was revision of previous 1-inch maps, and the remainder new survey. Except for a small bit of Siwālik hills in the north-east, the country was fairly open plains, of which more than half was well irrigated by perennial canals.

The party was in the field 6 months, and the average staff actually out in the field surveying, apart from men sent to Delhi and plotting, was 4 assistants, 32 surveyors and 6 beginners, the outturn being 29 sheets.

The field work was at first delayed by the necessity of keeping one section for 2 months plotting traverse data in the field, and later by the sudden transfer of 1 officer and 4 men to special work at Delhi.

The topography was divided into 4 camps under the 4 Provincial Officers Subedar Kanak Singh, Mr. Saubolle, Mr. O'Sullivan and Mr. McCraken.

Mr. O'Sullivan with 4 surveyors and 5 draftsmen was employed in plotting traverse data for the new survey up till middle of January.

About $\frac{3}{4}$ of the work was revision survey on 1-inch blue prints of old 1-inch sheets. New survey based on plotted trijunctions was only necessary in Sialkot, Gurdāspur and Amritsar districts, with the exception of sheets $44\frac{I}{10,\,14,\,15}$ in Amritsar district, for which previous 1-inch maps were available.

The Siwālik portion of $44\frac{M}{14}$ was revised on $1\frac{1}{2}$-inch blue prints.

No new triangulation or traversing were required.

A detailed analysis of outturn gives most confusing results, and I can only roughly gather that under more settled circumstances we might expect between 40 and 50 miles of 1-inch revision survey and between 30 and 40 miles of 1-inch new survey per man per month. The actual average for the work for the whole season appears to be about 38 miles.

The cost-rates for the field season's work do not appear to afford satisfactory results in regard to the comparative costs of different kinds of survey, but give a rough average cost of Rs. 8·5 per square mile for field work, and Rs. 3·2 for fair mapping of the regular work of the party, excluding the cost of special areas, and other extraneous charges not pertaining directly to the party.

Recess duties.—The whole of the fair mapping was completed and sent in by the end of recess, and the party has no arrears of work of any kind on hand.

Owing to a variety of causes, (*e.g.*, the number of inferior draftsmen who had to be employed in order to get the work through and the charges of personnel during the early part of the recess), the fair drawing has not been altogether satisfactory in point of neatness or uniformity.

The fair drawing was made from $1\frac{1}{2}$-inch blue prints on tracing paper which were enlarged by photography from the 1-inch plane-tables. A great deal of delay and a certain amount of inaccuracy arose from all the canals in blue failing to appear on these blue prints, so that they had to be entered up on them by hand with proportional compasses.

Arrangements are to be tried in the coming season to prevent a recurrence of this difficulty.

No. 3 PARTY (UNITED PROVINCES).

BY CAPTAIN M. N. MACLEOD, R.E.

The country surveyed consisted of the alluvial plains of the Ganges valley and comprised portions of the following districts of the United Provinces :—

Hardoi, Farukhābād, Moradābād, Budaun, Bareilly, Etah, Shahjahānpur, and a small portion of Rāmpur State.

PERSONNEL.

Imperial Officers.

Captain A. A. McHarg, R.E., in charge from 1st October 1911 to 23rd March 1912.
Captain M. N. MacLeod, R.E., in charge from 23rd September 1912.
Lieutenant A. A. Chase, R.E., in charge from 15th May 1912 to 22nd September 1912.
Lieutenant R. S. Wahab, I.A., attached from 1st October 1911 to 11th October 1911 and from 21st April 1912.

Provincial Officers.

Mr. B. M. Berrill, in charge from 24th March 1912 to 14th May 1912.
Mr. A. C. Bose.
Mr. P. A. T. Kenny.
Mr. H. C. W. Stotesbury, from 1st October 1911 to 21st February 1912.
Mr. B. C. Newland, from 1st October 1911 to 1st December 1911.
Mr. A. J. A. Drake.
Mr. F. H. Grant.
Mr. F. J. Grice.
Mr. J. A. Calvert, from 1st October to 28th October 1911.

Upper Subordinate Service.

Mr. Lutf Ali, Probationer.

Lower Subordinate Service.

16 Surveyors, permanent.
13 Surveyors, temporary.
6 Soldier Surveyors.
2 Clerks.
8 Temporary Draftsmen, Typers, and Pupil Surveyors.

The whole area under survey was cultivated, poppy and sugarcane being the most valuable crops.

The country was flat with a few sandy knolls, but the level of the small portion of the country west of the Ganges from Kanauj in the south-east corner to Fatehgarh, (where the right bank of the Ganges has a relative height of 25 to 30 feet), and thence in a north-west direction away from the river, is perceptibly higher than the country between the Ganges and the Ramganga, the level rises again east of the Ramganga.

Except to the north-west of Farukhābād where the course of the Ganges has moved eastward, the courses of both the Ganges and the Ramganga appear to have been oscillatory.

From the quantity and quality of the crops along the Ramganga river it would appear that the silt deposited by this river is richer than that of the Ganges.

Though the country cannot be called well wooded, there are numerous mango groves, and all the main roads have good avenues of trees.

The field office opened at Bareilly on November 1st and closed on April 20th. The recess office opened at Mussoorie on April 25th. The health of the party was generally good.

Topography.—The area surveyed during the year was 6187·38 square miles comprising sheets 53 $\frac{L}{9,\,10,\,11,\,12,\,13,\,14,\,15 \text{ and } 16}$, 53 $\frac{P}{3,\,4,\,7,\,8,}$ and 54 $\frac{M}{1,\,2,\,5,\,6,\,9,\,10,\,11,\,12,\,13,\,14, \text{ and } 16}$, 23 1-inch sheets in all. The whole of this was revision survey on the scale of 1 inch=1 mile. Sheet 54 $\frac{M}{15}$ formed part of the programme, but could not be completed, as the greater portion of it lay within the Bilgram tahsil, for which the traverse data were insufficient. With this exception the programme laid down for the field season was completed.

The work was carried out on blue prints of the latest edition of the existing 1-inch maps in new 1-inch sheet sizes. These, except in the country near the large rivers where these had changed their courses, were generally found to be most accurate.

Two blue prints of the Budaun district were received without trijunctions and in these two field sections the trijunctions were surveyed by fixing from junctions of roads, corners of villages and other well-defined points which could be identified on the ground.

G. T. points throughout the area were few and far between and lines of levelling with G. T. Bench-marks only ran through 4 sheets, but considerable use was also made of old level charts for fixing heights.

The party was divided into 5 camps as under:—

I. Mr. B. M. Berrill, E. A. S., up to 23rd March 1912 and Mr. F. J. Grice, S. A. S., from 24th March 1912 with 9 surveyors at Fatehgarh.

II. Mr. A. C. Bose, E. A. S., with 8 surveyors at Chandausi.

III. Mr. P. A. T. Kenny, E. A. S., with 8 surveyors, at Budaun.

IV. Mr. A. J. A. Drake, S. A. S., with 6 surveyors at Shahjahānpur.

V. Mr. F. H. Grant, S. A. S., with 6 surveyors at Moradābād.

No triangulation or traversing were done by the party during the year.

The average outturn per man per month was 34·9 square miles and the cost-rates were, 1-inch revision survey, Rs. 9-0-4 per square mile, and fair mapping, Rs. 4-12-6 per square mile. The outturn was rather small considering the nature of the work, but the average was considerably lessened by one provincial officer and 10 of the best surveyors being deputed to the Delhi 4-inch=1 mile survey at a time when work was in full swing.

Recess duties.—During the recess the whole 23 1-inch sheets surveyed were fair mapped on the $1\frac{1}{2}$-inch scale. Fifteen of these have been completed and submitted to the Superintendent, Northern Circle, and the remainder will be sent in by October 15th.

The spelling of village names has again given trouble. It would appear that the best solution of the difficulty is for camp officers to take the local pronunciation and to decide the correct spelling "on the spot". District officials have neither the time nor the inclination to correct long lists of names, particularly in the United Provinces, where it is not uncommon to find 400 or 500 names in a sheet.

Though there were no contour sheets to be prepared the time usually spent on them was fully taken up by the extra typing necessary on account of the large number of villages, and it was found that in order to complete the 23 sheets during $5\frac{1}{2}$ months of recess, it was necessary to arrange that typing should proceed concurrently with the outline drawing, the draftsmen working from 6 A.M. till noon and the typer from noon till 6 P.M. or else one of them working on Saturday and Sunday and taking two days' leave during the week.

To carry out this system satisfactorily it is imperative that the spelling of all names should be checked and the correct spelling entered on the plane-table sections while in the field, so that the section officer on arrival in recess is free to devote his time to the examination of traces, the preparation of guides for the typers and the supervision of the drawing.

Unfortunately owing to the very great expansion and contraction of the blue prints on which the survey was done, it was impossible to enlarge them to correct dimensions, and this precluded the possibility of fair drawing direct on to blue prints.

This excessive expansion and contraction is principally due to the necessity of wetting such prints before mounting, and, where it is otherwise possible to obtain blue prints on drawing paper for fair drawing, it would be preferable to have the prints of previous work separate on tracing paper, and transfer them by hand on to a board previously mounted and allowed to dry. This would entail some extra labour on taking the field, but it is probable that the field sections would not be too distorted to permit of the enlargements being made to

scale and printed direct on to drawing paper, and much labour would thus be saved during the recess.

The map of Delhi and vicinity on the scale 4 inches=1 mile, surveyed by the Delhi Detachment in April and May 1912, was drawn and will be published by 15th October 1912.

There were no computations to be done in recess and no arrears of drawing, etc., at the close of it.

No. 4 PARTY (UNITED PROVINCES).

By CAPTAIN L. C. THUILLIER, I.A.

The field head-quarters of the party remained at Sitapur throughout the field season; the recess head-quarters continued at Mussoorie.

PERSONNEL.

Imperial Officers.

Captain L. C. Thuillier, I.A., in charge.
Lieutenant F. B. Scott, I.A.

Provincial Officers.

Mr. G. J. S. Rae.
Mr. H. W. Biggie.
Mr. C. E. C. French.
Mr. J. C. Lears, from 13th December 1911.
Mr. A. B. Hunter.
Mr. G. E. R. Cooper.
Mr. J. A. Calvert, from 29th October 1911 to 29th May 1912.
Mr. A. F. Murphy, from 11th October 1911.

Upper Subordinate Service.

Jemadar Mohammad Husain Khan.

Lower Subordinate Service.

34 Surveyors.
1 Traverser.
9 Draftsmen.
4 Computers.
2 Clerks.
2 Typers.
6 Soldier Surveyors.

The cantonment section had its field and recess quarters at Quetta, as field work was continued there throughout the year.

The programme of the party and locale of operations continued in the United Provinces.

The country under survey consisted for the most part of similar country to that surveyed last season, *viz.*:—a flat plain generally well cultivated and interspersed with an abundance of groves and occasional stretches of "usar" plains. On the east of the work, however, along the Gogra river and its tributaries, occurred a broad tract of country lying at a lower level than the surrounding plain and cut up by innumerable streams and backwaters. This country for the first 2 to 3 months was considerably flooded. The Gogra was the only large river in the area under survey this season. The Gumti, which is a considerably smaller river, ran through two or three of the sheets under survey.

The field season commenced on the 30th of October 1911 and closed on the 6th of April 1912.

The health of the party was good throughout the season. Plague occurred during the season, but was not really so severe as the previous season, and no cases occurred among the party. One case of cholera occurred which unfortunately ended fatally. Though it was expected that in the Gogra tracts men would suffer from fever, this did not occur, possibly owing to the issue of quinine for a month before taking the field.

Topography.—The programme of this work consisted of the survey on the 1-inch scale of sheets 63 $\frac{A}{3,4,7,8,10,11,12,15,16}$ and 63 $\frac{E}{3,4,7,8}$, and the supplementary survey only of sheets 63 $\frac{A}{1,2,5,6,9,13,14}$, 63 $\frac{E}{1,2,5,6}$.

Sheets 63 $\frac{A}{1 \& 2}$ were subsequently cut out of the programme, as the party had to send surveyors to do special work at Delhi.

The whole area for survey lay in the districts of Sitapur, Hardoi, Kheri, Lucknow, Bahraich and Bara Banki.

The area in districts Kheri and Bahraich was merely supplementary survey, as the current maps of these portions had been compiled from 16-inch cadastral

surveys carried out only about 15 to 17 years ago. The remaining portions had not been surveyed since the original survey done about 1860-63, and, as the old maps were much wanting in detail, and also were of practically no use to surveyors, it was considered advisable to survey the whole area anew.

A certain number of surveyors and draftsmen were kept at head-quarters to complete the fair sheets which were not completed in recess. This was found a much longer job than was originally anticipated, and the last sheets did not go in till March.

At the end of March, 6 surveyors, under Mr. Calvert, were sent to Delhi to do special work there under Lieutenant Chase.

Field work continued till early in April when the head-quarters of the party and the majority of the surveyors proceeded to recess quarters, Mr. J. C. Lears and one or two surveyors remaining behind for a short time to complete their work.

The surveyors for topographical work were distributed into 5 camps under Lieutenant Scott, Messrs. G. J. S. Rae, H. W. Biggie, A. B. Hunter and G. E. R. Cooper.

Lieutenant Scott's camp consisted of Jemadar Mohammad Husain Khan, U. S. S., 4 surveyors and 1 soldier surveyor. The camp's operations lay in the eastern portion of the party's work along the Gogra river in districts Kheri, Sitapur, Bahraich and Bara Banki.

Mr. Rae's camp consisted of 4 surveyors only. The camp's operations lay in the northern portion of the party's area, in districts Kheri and part of Sitapur.

Mr. Biggie's camp consisted of Mr. Calvert and 8 surveyors and 2 soldier surveyors. The camp's operations lay in the western portion of the party's area, in districts Hardoi and Sitapur.

Mr. Hunter's camp consisted of Mr. Murphy, 6 surveyors and 3 soldier surveyors. The camp's operations lay in the western centre of the party's area, in district Sitapur.

Mr. Cooper's camp consisted of 7 surveyors and 2 soldier surveyors. The camp's operations lay in the eastern centre of the party's area, in districts Sitapur, Lucknow and Bara Banki.

Towards the end of the field season, a slight redistribution of surveyors was found necessary to complete the work.

The average rate of plane-tabling (excluding the time taken by the men in marching to their work), was 36·89 square miles per mensem for survey and 66·34 square miles per mensem for supplementary survey.

The cost-rates were as under:—

Detail survey, 1-inch scale, 5,807 square miles at Rs. 10·04 per square mile.

Traversing.—This only consisted this season of running supplementary lines of traverse, where it was found that surveyors were short of points on which to adjust their work.

Cantonment Surveys.—This section was under Mr. C. E. C. French with 2 computers, 5 surveyors, 2 draftsmen, 1 typer and 55 menials.

The only Cantonment taken up during the year under report was that of Quetta.

We were requested to carry out the following surveys:—

(*a*) The survey of Quetta Cantonment on the scale 16 inches=1 mile, area about 17 square miles.

(*b*) A survey of the Fort, scale 50 feet = 1 inch, area about 53 acres.

(*c*) A survey of some 700 acres of waste land lying north-west of cantonment limits for the extension of ranges.

The 16-inch map of the cantonment was to show contours at 5 feet vertical interval.

Later on we were requested by the Civil authorities to do a survey of Quetta Civil Station on the scale of 16 inches to 1 mile comprising an area of about 1,100 acres.

These surveys are still going on, but the field work should be completed by December. The fair drawing is being carried on, where possible, at the same time as the field work.

Proofs of 5 cantonments were received for colouring during the year, *viz.* :—Allahābād, Hyderābād, Risālpur, Loralai and Fort Sandeman.

The area surveyed during the season and cost-rates are not yet available, as the survey of Quetta Cantonment is not completed.

The total cost of this section for the year was Rs. 21,206.

Recess duties.—All fair maps of the sheets surveyed during the field season were completed and sent for publication before the end of the recess. This was a considerable improvement on last season as no sheets were sent for publication before the end of recess last year. The previous season's work had however been a useful experience, and by altering the system, we were able to complete our fair mapping of 22 sheets during the recess.

RIVERAIN DETACHMENT.

BY MR. MAYA DAS PURI, R.S.

PERSONNEL.

Provincial Officers.

Mr. Maya Das Puri, R.S., in charge.
Mr. Moqim-ud-din.

Upper Subordinate Service.

Mr. Chuni Lal Kapur.

Lower Subordinate Service.

2 Surveyors.
35 Traversers.
25 Draftsmen.
27 Computers.
2 Clerks.

SETTLEMENT STAFF.

Malik Wali Rām, *Tahsildar.*
Mir Nāsir Ahmed, *do.*
Mehta Gand Ram, *Naib Tahsildar.*
Malik Ahmedyar Khan, *ditto.*
Sheikh Mahbūb Ali, *ditto.*
Chaudhri Jalāl Din, *ditto.*
Chaudhri Imām Din, *ditto.*
Mian Ghulam Murtaza, *ditto.*
28 *Kanungos.*
120 *Patwaris.*
1 Reader.
1 *Názir.*
3 Clerks.
9 *Moharrirs.*
1 Sub-Assistant Surgeon.

The office of the detachment remained at Multān throughout the field season, and returned to Lahore on 20th June 1912 for recess. It was shifted again to Multān on various dates during September 1912.

The riverain area under survey was broken, shrubby, sandy, and marshy. Portions of villages, situated above the high banks, were well cultivated, and parts of the Una and Garhshanker tahsils were hilly.

The Lower Bari Doāb tract was flat, in parts heavily wooded and covered with forest reserves and small sand hills, sparsely inhabited towards the north near the Rāvi: and mostly waterless and unpopulated.

The field season commenced on 1st October 1911, and closed in the middle of June 1912. The Lower Bari Doāb work was re-started on the 1st of September 1912.

The health of the detachment was good all round the year. Two *khalāsis* and two computers died.

I. *The Riverain Survey.*

(*a*) *Work done for the cadastral surveys of Riverain estates.*

The detachment continued its work of traversing and laying down base lines during the year. 332·95 linear miles of main traverse, and 1911·26 linear miles of minor traverse were run; 8,541 theodolite stations were fixed along the banks of the rivers Sutlej, Rāvi, Chenāb and Jhelum in districts Hoshiārpur, Ambālā, Ferozepore, Lahore, Montgomery, Sialkot, Gujrat, Shahpur, and Jhelum; and 492 corners of 164 squares were marked with permanent mark-stones on both banks of the Sutlej and the Jhelum to serve as bases for the future demarcation of boundaries in the bed of the rivers. 1,997 plotted and 485 boundary *masāvis*, (settlement mapping sheets), of 328 villages were completed, and 30 four-inch sheets were traced and supplied in time to the Settlement Officers of Hoshiārpur, Una, Ferozepore, Sialkot, and Shahpur.

Besides these 129 miscellaneous traces were prepared, and all the traverse stations, laid out during the season, were plotted on 28 four-inch sheets.

The following two tables show the outdoor and office work done for cadastral survey:—

A.—OUTDOOR WORK.

Scales 200, 220, 191⅓, and 190 feet = One inch.

Names of Rivers, Districts and Scales.	Straight length in miles.	Main circuits.			Minor Traverses for Detail Survey.				Base Lines.		
		No. of square miles.	Linear miles.	No. of theodolite stations.	No. of square miles.	Linear miles.	No. of theodolite stations.	No. of villages.	No. of corners.	No. of squares.	Area in square miles.
Sutlej River.											
Ferozepore, Lahore, and Montgomery, scales 200 and 220 feet = 1 inch.	15	73	73·34	106	...	...	...	...	...	...	...
Ferozepore and Lahore, scale 200 feet = 1 inch.	8	48	36·65	80	59	367·25	1556	59	132	44	38·38
Hoshiārpur and Ambālā, scales 191⅓ and 190 feet = 1 inch.	28	...	...	...	81	435·41	1831	77	117	39	...
Ferozepore and Jullundhur, scale 200 feet = 1 inch.	24	...	...	...	38	296·36	1376	9	99	33	28·94
Jhelum River.											
Shahpur and Jhelum, scale 220 feet = 1 inch.	29	70	70·70	124	65	367·52	1418	35	144	48	48·78
Chenāb River.											
Sialkot and Gujrat, scale 220 feet = 1 inch.	30	103	83·98	116	...	..	...	...	...	...	...
Gujrat and Gujranwala, scale 220 feet = 1 inch.	32	134	67·98	91	...	...	...	...	...	...	...
Rāvi River.											
Sialkot and Amritsar, scale 200 feet = 1 inch.	...	...	...	...	92	444·69	1923	98	...	...	...
TOTAL	166	428	332·95	517	335	1,911·26	8024	328	49	164	116·10

B.—OFFICE WORK.

Name of River.	Name of District.	Scale.	No. of plotted *masāvis*.	No. of compiled *masāvis* showing Riverain boundaries.	4-inch sheets traced for the use of Settlement Officers, (scale 4 inches = one mile.)	No. of 4-inch sheets on which new work was plotted.
Sutlej . .	Ferozepore .	200 feet = 1 inch	621	190	8	8
Sutlej . .	Hoshiārpur . . and Ambāla .	$191\frac{2}{3}$ „ = 1 „ 190 „ = 1 „	526	111	8	6
Jhelum .	Shahpur .	220 „ = 1 „	273	61	6	6
Rāvi . .	Sialkot .	220 „ = 1 „	577	123	8	8
		TOTAL .	1,997	485	30	28

Besides these 129 miscellaneous traces were prepared during the year.

(*b*) ***Work done for the 4-inch compilation of Riverain boundaries.***

20 sheets were plotted and compiled, 23 sheets finally completed, 10 sheets typed; and 371 villages were reduced by pantograph to the scale 4 inches=one mile.

The progress of the work is clearly shown in the table below :—

Name of River.	Name of the series.	No. of sheets plotted and compiled.	No. of sheets finally examined.	No. of sheets typed.	REMARKS.
Sutlej .	Jullundur. Ferozepore.	...	...	$\frac{4}{8}$	
Sutlej .	Hoshiārpur. Ambāla.	...	1	$3\frac{4}{8}$	
Sutlej .	Ferozepore. Kapurthala State.	...	1	1	In addition to these sheets the settlement maps of 371 villages were reduced by pantograph.
Jhelum	Jhelum. Shahpur.	...	2	...	
Jhelum .	Shahpur.	...	9	...	
Jhelum .	Jhelum. Gujrat.	...	4	...	
Chenāb .	Shahpur. Gujranwala.	...	...	5	
Rāvi .	Montgomery.	15	...	...	
Rāvi . .	Lahore.	...	6	...	
Jumna .	Ambāla. Sahāranpur and Karnal.	5	...	...	
	TOTAL .	20	23	10	

II. *The Lower Bari Doāb 25-acre Rectangular Survey.*

This work was carried over the remaining tract commanded by the Lower Bari Doāb Canal. The Settlement Staff continued joining the detachment till late in December 1911, and consequently a considerable time was spent in training the hands. As after May 1912 it became very difficult to work out during the day time on account of excessive heat, scarcity of water, and dust storms, the field operations were temporarily stopped in the middle of June 1912 and restarted on the 1st of September 1912.

The whole of the Settlement Staff was employed on this class of work; and the two Sub-Assistant Superintendents with 20 traversers assisted in forming blocks of 80 to 100 rectangles.

In all 55,000 (fifty-five thousand), 25-acre rectangles were broken. Nearly 40 per cent. of the work was tested by the *Naib Tahsildars, Tahsildars* and the Survey Officers; and 15 per cent. was checked with theodolite traverse. 4,782 linear miles of traverse were done and 13,788 theodolite stations were fixed.

The maximum linear error admissible was one in every five hundred except in very few cases where the error was allowed a little heavier than this from base to base, because the traverse values from which the bases had been originally computed were not so good; and it was not possible to better them then. The base line pillars were shifted and put right wherever they were found out of their true positions. This retarded the progress of work considerably.

As the initial bearing of the base lines was doubtful within 5′, and there was also linear error in the work, in several cases the angular work between two bases generally 10 to 12 rectangles apart, was closed by allowing $\frac{1}{2}'$ per corner of a rectangle, or 1′ per theodolite station while breaking the intermediate rectangles. In all such cases the angular work of traversers was carefully checked in order to ascertain that there was no serious error in their work.

With the view to save time and unnecessary labour 100 feet instead of 66 feet chains were used in the Lower Bari Doāb computations for the purpose of cutting the 25-acre rectangles.

The method of distributing errors and general procedure adopted, was the same as described in the last year's report.

The riverain main circuits on the Sutlej were connected with Karni Khera T. S., and Pir Ghani T. S., and on the Chenāb with Jeto T. S., Bala T. S., Sadulapur T. S., Hela T. S., and Ranjit Garh T. S.

The Lower Bari Doāb traverse was connected with Mega T. S. for laying out extra base lines near the Rāvi river.

The average errors in the riverain work were:—

(*a*) Main circuits.
  Angular error 3″·2 per station.
  Linear error 0·10 link per 10 chains.

(*b*) Minor traverses.
  Angular error 2″ per station.
  Linear error 0·38 link per 10 chains.

(*c*) Base lines.
  Error per corner 3 feet in direct distance, when compared with its theoretical value.

The temporary riverain *khalāsis* were paid directly by the Settlement officers concerned. The total expenditure of the detachment from 1st October 1911 to 30th September 1912, excluding the pay of the above men, was Rs. 2,26,002 as detailed below:—

		Rs.	
Riverain	.	24,969	
Lower Bari Doāb	.	2,00,981	(*i.e.*, annas 2·34 per acre).
Delhi Survey	.	52	
TOTAL	.	2,26,002	

THE SPECIAL DELHI SURVEY DETACHMENT.

BY MAJOR C. H. D. RYDER, D.S.O., R.E.

Owing to the transfer of the Capital of India from Calcutta to Delhi, a Town-planning Committee was sent from England. In order that all information should be ready on their arrival, a detachment was formed to carry out the work. This detachment was in charge of Lieutenant A. A. Chase, R.E., with Syed Zille Hasnain, the officer in charge of No. 17 Party, in charge of the levelling.

On the 18th of March orders were issued for a revision survey on the 4-inch scale together with contours at 5 feet vertical interval of Delhi and the vicinity. 18 surveyors, 3 provincial officers and a levelling detachment of 4 levellers and a provincial officer in charge arrived in Delhi, the former by 30th March, the latter by 29th March.

It was decided that the area should be revised on blue prints on drawing paper of the old 4-inch Revenue survey in the ordinary way. These blue prints arrived in Delhi on 29th March.

It was pointed out that the Town-planning Committee would arrive on the 14th April, and that, as the Committee could do little without the aid of a 4-inch contoured map, it was essential that copies should be got out with the utmost expedition.

As the copies of maps were urgently required, it was decided to send in 3 plane-tables each night by 9 P.M. to head-quarters, where these were traced during the night and returned to the plane-tablers by 5 A.M., so that the traces kept pace with the survey.

The exact area to be surveyed could not be actually defined until the Committee arrived, but it was realized that there was information regarding levels north of Delhi and none south, and that what is known as the "southern site" was the more important, and so it was decided to concentrate the surveyors and levelling detachment south of Delhi, and to rely on the existing 2-inch survey of 1910-11 and Irrigation Department levels for the north of the city.

As there were not sufficient triangulated heights in the area under revision, the surveyors were instructed to leave the contouring until the detail was surveyed, and the levelling detachment were instructed to run in the meantime a network of levels which would give lines most useful to an engineer, as well as giving numbers of heights to surveyors.

Level lines were therefore run along nullahs, and in some few cases along ridges, traces of the level lines with descriptions and reduced levels were given to the surveyors concerned at the end of each day's work to enable the latter to fix the position of these on the plane-tables as their work progressed.

On April 24th, the Committee gave their opinion that the area being revised was probably sufficient for their purpose.

The detail survey was finished by April 25th, and by this time levels had been run practically all over the area under survey and over which Irrigation Department levels were not available.

On the 4th May, the Committee decided that the area under revision should be extended slightly. Levellers and surveyors, who had practically all come in to head-quarters by this date, were sent out to do this extra detail, which it was decided to insert on the traces, after copies of the area first agreed upon had been delivered.

By the 5th May the contouring was finished, and on the 7th of May the traces were sent to Calcutta for a vandyked edition, 30 copies in black and brown being delivered into the hands of the Committee on the 13th of May.

On the 22nd of May, the extra area had been levelled, surveyed, contoured and inserted on the traces, and these traces have since been sent for a further edition in black and brown with level lines surprinted in red.

The map was fair drawn in four sheets with great rapidity, and the Town-planning Committee were supplied with all the copies required.

HENRY CHARLES HUBERT COOPER,

Born—5th August 1874.

Died—27th November 1912.

SOUTHERN CIRCLE.

(*Vide* Index Maps 2 and 5.)

The Southern Circle was under the superintendence of Brevet-Colonel T. F. B. Renny-Tailyour, C.S.I., R.E., throughout the year.

The circle consisted of Nos. 5, 6, 7 and 8 Parties.

During the year 9,115 square miles were surveyed, 7,614 square miles were triangulated and 889 linear miles were traversed by theodolite. The cantonment of Santa Cruz was also surveyed.

The survey consisted of:—

5,670 square miles of 1-inch survey.
1,329 " " " " revision survey.
1,341 " " " 1½-inch survey.
119 " " " " revision survey.
656 " " " 2-inch survey.

The smallness of the outturn is principally due to the parties being under strength, to the large area and the difficult nature of the reserved forests and to the extremely intricate character of the country along the west coast of Madras.

Descriptions of experiments as regards the plane-tabling and fair mapping are given in the reports of Nos. 6 and 7 Parties.

NOTE.—The following method of mounting a mill board for plane-tabling was suggested by Mr. A. Ewing and was given a trial, with very satisfactory results, during the field season in this circle:—

(*i*) Cut down a piece of mill board to 30 inches × 24 inches, that is, to the size of a plane-table.

(*ii*) Paste sheets of rag-litho paper firmly on both sides of the mill board. This is done to avoid the colour from the mill board staining the drawing paper when mounted.

(*iii*) Paste a sheet of 210 lbs. drawing paper 30 inches × 24 inches on to the centre of a piece of *malmal* or any fine white cloth 42 inches × 36 inches. This should be done on an ordinary table, the cloth should first be washed and, after the drawing paper has been pasted on to it, should be stretched and pinned down to the table and allowed to dry for a couple of days.

(*iv*) The mounted sheet of drawing paper should then be lightly pasted on the mill board.

(*v*) Cut the cloth that projects round the mill board into strips about 4 inches wide and paste alternate strips under the mill board.

(*vi*) The mounted mill board should, if possible, be passed through a printing press.

(*vii*) Project and plot the board.

(*viii*) Place the mill board on a plane-table and paste the other strips, referred to in (*v*), under the plane-table, but only about 3 inches at the ends of the strips should actually be pasted, so that, when the plane-table expands or contracts in the field, the loose cloth will give to it.

N.B.—When working in a very damp climate the mill board should be varnished and allowed to dry before being mounted. Metal corner clips could be used for fixing the mill board on the plane-table, but pasting is better as a surveyor can very easily take off the mill board and repaste it if he finds that the mill board does not lie flat on the plane-table.

No. 5 PARTY (CENTRAL PROVINCES).

BY LIEUTENANT K. W. PYE, R.E.

The programme of the party included survey and revision survey on the 1-inch scale and triangulation in parts of degree sheets 55-I, 55-J, 55-K, 55-O and 64-A, comprising portions of the Gwalior and Bhopāl States of Central India and of the Hoshangābād, Narsinghpur, Chindwāra, Seonī, Betūl, Nāgpur, Bhandāra and Jubbulpore districts of the Central Provinces.

PERSONNEL.

Imperial Officers.

Major C. L. Robertson, C.M.G., R.E., to 19th March 1912, and in charge to 31st January 1912 and from 11th March 1912 to 19th March 1912.
Lieutenant K. W. Pye, R.E., from 1st January 1912, and in charge from 1st February 1912 to 10th March 1912 and from 20th March 1912.
Lieutenant C. G. Lewis, R.E., from 1st June 1912.
Lieutenant C. F. Nation, R.E., to 2nd December 1911.

Provincial Officers.

Mr. F. P. Walsh.
Mr. J. H. S. Wilson from 20th May 1912.
Mr. S. S. McA'Fee Fielding from 22nd May 1912.
Mr. P. Kennegy from 15th November 1911 to 30th June 1912.
Mr. C. West.
Mr. F. C. Pilcher.
Mr. Munshi Lal.
Mr. C. O. Picard.

Upper Subordinate Service.

Mr. Eknath Battu.
Mr. Ram Narayan Hastir.

Lower Subordinate Service.

23 Surveyors.
3 Soldier surveyors.
3 Computers.
2 Pupil surveyors.
2 Clerks.

Sheets 55 $\frac{I}{4}$ and 55 $\frac{J}{2,6,7,10}$ contained some very broken and difficult country, the country in sheets 55 $\frac{I}{8}$ and 55 $\frac{J}{9,13}$ was flat or undulating, while in the remainder of the sheets the country was of a varied nature.

The field season opened at Jubbulpore on the 3rd November 1911 and closed at the same place on the 8th May 1912.

During most of the field season the head-quarters of the party was located at Pachmarhī.

The health of the party was fair.

Topography.—To carry out the 1-inch survey three camps were formed while two surveyors working independently were deputed to complete the area for revision survey in the Jubbulpore district which had been commenced in the previous year. The following allotment of work was made :—

No. 1 camp, sheets 55 $\frac{I}{2,3,4,7}$ in the Gwalior and Bhopāl States.

No. 2 camp, sheets 55 $\frac{J}{2,6,7,10}$ in the Hoshangābād, Chindwāra, Betūl and Narsinghpur districts.

No. 3 camp, sheets 55 $\frac{I}{8}$ and 55 $\frac{J}{9,13}$ in the Bhopāl State and in the Hoshangābād and Narsinghpur districts.

Revision survey, sheets 64 $\frac{A}{2,3,6,7}$ in the Jubbulpore district.

The survey of all the above sheets was completed except sheet 55 $\frac{J}{10}$ which remained unfinished at the close of the season. The outturns were 2,569 square miles of 1-inch survey and 904 square miles of 1-inch revision survey, making a total of 3,473 square miles.

Triangulation.—Three officers were employed on triangulation and completed sheets 55 $\frac{K}{14,15}$ and 55 $\frac{O}{2,3,4,6,7,8,12}$ in the Nāgpur, Bhandāra, Chindwāra and Seonī districts. The country extended over the long southern wooded slopes of the Central Provinces plateau down to the low undulating country round Nāgpur. The area triangulated amounted to 2,493 square miles.

Recess duties.—The mapping of the revision sheets 64 $\frac{A}{2,3,6,7}$ was handed over to the Southern Circle Drawing Office and ten sheets, *viz.*, 55 $\frac{I}{2,3,4,7,8}$ and 55 $\frac{J}{2,6,7,9,13}$ were left in hand for fair drawing, these latter sheets were completed by the end of the recess. Of sheet 55 $\frac{J}{7}$, which contained the heaviest work of any sheet, the party was fortunate in obtaining enlargements on tracing paper sufficiently true to scale to enable them to be pasted on to the prick-off sheet and vandyked direct. Of one other sheet half was enlarged and printed on drawing paper as a direct drawing print, the other half being transferred by hand, while the remaining sheets were prepared by the method of vandyking traces.

The computation of the triangulation for the ensuing season's work was completed during the recess. Three degree charts, *viz.*, 55 I, 55 M and 54 P, with tables of data were prepared.

No. 6 PARTY (BERĀR AND HYDERĀBĀD).

BY MAJOR H. WOOD, R.E.

The work of the party continued in the previous theatre of operations, *viz.*, Berār and Hyderābād.

PERSONNEL.

Imperial Officers.

Major H. Wood, R.E., from 17th December 1911 and in charge from 19th December 1911.
Lieutenant K. W. Pye, R.E., to 31st December 1911 and in charge to 18th December 1911.
Lieutenant C. F. Nation, R.E., from 3rd December 1911 to 3rd April 1912.

Provincial Officers.

Mr. J. H. S. Wilson to 19th May 1912.
Mr. P. R. Anderson to 15th October 1911.
Mr. E. A. Meyer.
Mr. F. B. Kitchen.
Mr. R. B. Gildea.
Mr. J. O'C. Fitzpatrick.
Mr. A. J. Moore.
Mr. A. V. Dickson from 14th October 1911.

Upper Subordinate Service.

Mr. Dharmu to 22nd May 1912 and from 23rd August 1912.

Lower Subordinate Service.

19 Surveyors.
1 Soldier surveyor.
1 Draftsman.
6 Traversers.
2 Computers.
5 Pupil surveyors.
2 Clerks.
1 Sub-assistant surgeon.

The scene of survey lay in the valley of the Pengangā river and the hills lying to the north and south of it. The country on the west of the area was mostly open plateaux but, where they descend, the fall to the river is abrupt, and here the streams have cut deep ravines, making the country intricate and broken.

The field season began on the 14th October 1911 and closed on the 8th May 1912, lasting practically 7 months but, as the traverse camp began work a month before the rest of the party and one triangulator remained out until the middle of June, the field season for a considerable portion of the party was nearly 8 months in duration. The head-quarters of the party was located at Bāsim.

The health of the party, notwithstanding the fact that for the greater part of the season it was working in the unhealthiest part of Berār, was good; the surveyors and *khalāsis* suffered to some extent from fever, but these attacks did not last long and were not severe.

Topography.—As a considerable area of the country that would fall under survey in the next 2 or 3 years consisted of reserved forests, it was decided to survey as much of these forests as possible in advance of the general programme. This plan was adopted as much of the forest area is in small patches with very complicated boundaries and it had been found necessary to survey large areas outside the forests so as to adjust the margins of the work on the two scales. By surveying the forests in the year previous to the general survey on the 1-inch scale it will only be necessary to survey on the larger scale up to the forest boundaries as during the recess the forest survey can be reduced by photography to the 1-inch scale and the results transferred to the 1-inch plane-table sections in blue. The surveyor will use this in the ordinary way laid down for treating previously surveyed forests. This plan will also expedite the fair mapping as all the country will be on the 1-inch plane-table sections and there will be no troublesome adjustments on the traces between reductions and enlargements. For this reason the whole party, with the exception of the men under instruction and a few of the younger hands, was employed after Christmas entirely on forest work which fell in the area proposed for survey in the year 1912-13.

At the beginning of the season the surveyors were formed into two camps under Messrs. Wilson and Kitchen and were employed practically entirely on

1-inch work. After Christmas when the forests became more open, one camp, consisting of the men under training with one or two young surveyors, was formed under Mr. Meyer to complete the 1-inch programme, while the rest of the party was divided into two forest camps under Messrs. Wilson and Kitchen. A month before the close of the season another forest camp under Mr. Gildea was formed to survey a detached area.

With the exception of about 100 square miles of forest for survey on the 2-inch scale, the programme of the party was completed. Sheets $56\frac{E}{1, 5, 6, 9, 13}$ were completely surveyed on the 1-inch and 2-inch scales and in addition the reserved forests in sheets $56\frac{E}{10, 14, 15}$ and $56\frac{I}{1, 5, 9}$. The outturn of survey was 1,745 square miles of which 408 square miles were executed on the 2-inch scale. The outturn per man per mensem (excluding men under training), was 19·2 and 8·1 square miles on the 1-inch and 2-inch scales respectively; this shows a falling off on last year on the 1-inch scale but an improvement of over 60 per cent. on the 2-inch scale. The lesser outturn on the small scale is accounted for by the fact that the ground was more difficult and also the better men were for the greater part of the season employed on the 2-inch scale. This latter reason also accounts for the improvement on the larger scale which was also helped by the fact that the individual forests were much larger in area.

Triangulation.—Triangulation was executed by three officers, only two of whom however were employed at the same time. Sheets $55\frac{D}{4, 8, 12, 14, 15, 16}$ and $56\frac{A}{1, 5, 9, 13}$, amounting to 2,800 square miles, were triangulated. The country was on the whole open and should not prove difficult to survey.

Traversing.—707 miles of reserved forest boundaries were traversed by theodolite and plots made on the 4-inch scale. The traverse camp under Mr. Meyer took the field a month earlier than the rest of the party and five temporary traversers were engaged for 2 months so as to enable the work to be done in advance of the detail survey.

Cantonment Surveys.—The cantonment of Santa Cruz, which had been traversed at the close of the field season 1910-11, was surveyed on the 16-inch scale at the beginning of the field season under report. It is of very small extent and did not take long.

Recess duties.—All the five standard sheets surveyed, *viz.* :—sheets $56\frac{E}{1, 5, 6, 9, 13}$, were fair mapped during the recess and in addition a sheet was drawn of the Santa Cruz Cantonment.

The computation of some of the intersected points of the triangulation was not completed nor was the final adjustment of about 180 miles of the forest traverse. This latter could not be done as it was executed in country which was triangulated in the year under report and the computations were not ready in time. These arrears are of no importance as the work is not required during the ensuing season.

NOTES.—Bristol boards and drawing paper mounted on mill boards were used during the field season for the field sections. A report has already been submitted on the results achieved and only the conclusion arrived at need be referred to here, this was that, in the very dry atmosphere in which this party works during the field season, bristol boards were freer from distortion than drawing paper mounted on mill boards and both were better than drawing paper mounted direct on to the plane-table as in the old method. The best method of mounting the bristol board was found to be to merely hold it down to the plane-table by corner clips leaving it quite free to expand or contract in all directions. When left perfectly free, expansion, etc., seems to be almost proportional in all directions but, if it is fixed in any way, distortion invariably takes place. Bristol boards will be used almost entirely for the field sections during the ensuing year and they will all be mounted so as to allow free expansion, etc., eight aluminium plane-tables will, it is hoped, be also available for use and they seem to offer at present the best solution of avoiding distortion in the field sections.

An experiment was tried this year of drawing all the fair sheets on bristol board. The stiff board which cannot be bent is somewhat difficult both to draw and type on and also to examine, but this defect cannot be said to counteract the manifold advantages this board has for drawing on. Whether this advantage is an inherent feature of bristol boards or whether it is due to the exceptionally smooth surface I am unable to say, but it is undoubtedly easier to draw finer and better lines and to type better on it than on the old pattern thick rough surfaced drawing paper. The thinner and more flexible board is the easier to manipulate.

A second experiment was tried in the fair mapping during this year, namely, the typing of all names, etc., that will appear in black on the published map on an entirely separate sheet. This was tried in the hopes that a better published map would result as the reproduction office can give different exposures for the fine drawing and the relatively coarser typing. A final decision as to the result can only be given when the sheets are published but incidentally the experiment has certainly shown that the typing of names, etc., separately is a great advantage in a party office. Drawing and typing can go on simultaneously and, the typing being spread over a long time, only the more efficient men need be employed on it. Under the old system practically every man who had the smallest knowledge of English and typing had to be employed towards the end of the recess to get the sheets finished. Also a badly typed word can be erased and typed elsewhere without spoiling any of the drawing, while better typing is also done. There is nothing else on the sheet to distract the attention so the work can be better criticised and examined. The method undoubtedly will throw extra work on the reproducing office as an extra plate has to be prepared but, as the registration has not to be very exact, this, except for the extra labour involved, need not be a troublesome business. Even if the published map is no better I think the system a very good one and I would certainly like to try it again another year.

Experiments were also tried to find out which was the most convenient method of drawing the traces. The old method of preparing a separate trace for each 5 minute square with separate traces for the detail and hill work is undoubtedly disadvantageous when the traces are transferred by vandyking, (as is adopted in this party), instead of by hand as in the older method. It was thought that making one trace for the whole sheet would offer most advantage, but experiment has shown that a trace on the $1\frac{1}{2}$-inch scale for a whole 1-inch sheet is too large and too cumbersome. It gets bent and creased in the preparation and even more so during the examination which is only done with great trouble. The general opinion after trying all possible groupings is that a strip of three 5 minute squares horizontally is about the best, but the shape of the original plane-table sections also affects the question. Another good arrangement is a block of 4 squares with a strip of 3 horizontally and another strip of 2 vertically. 3 squares horizontally or a square block of 4 seems to be about the limit which convenience of handling imposes. Both hills and detail should be drawn on the same trace. It is advisable to use green instead of blue for perennial streams and other water on the traces, while boundaries for jungle and cultivation limits are best shown by fine green and yellow lines. The drawing of roads in fine lines on the fair map is helped by showing all the roads on the trace in single lines, differentiating one class from another by different arrangements of breaks in the lines and if necessary by also writing their classification alongside in fine lettering on the traces. By using a single line in the centre of the road the lines of double lined roads are easier to draw finer, as the pen cannot be made to run as well over the blue vandyked lines as on the plain drawing paper and also the thickness of the inked line cannot be so well judged.

No. 7 PARTY (MADRAS).

BY MR. W. M. GORMAN.

PERSONNEL.

Imperial Officers.

Captain C. P. Gunter, R.E., in charge from 1st June 1912 to 30th June 1912.
Lieutenant J. D. Campbell, R.E., from 1st June 1912 and in charge from 1st July 1912.

Provincial Officers.

Mr. W. M. Gorman to 10th June 1912 and in charge to 31st May 1912.
Mr. J. O'B. Donaghey to 6th February 1912 and from 1st June 1912.
Mr. P. R. Anderson from 1st February 1912.
Mr. H. D. W. Stotesbury.
Mr. H. H. P. Butterfield.
Mr. J. C. St. C. Pollett.

Upper Subordinate Service.

Mr. Abdul Hakk, K.S.
Mr. K. Mandanna.

Lower Subordinate Service.

19 Surveyors.
2 Soldier surveyors.
1 Traverser.
1 Computer.
1 Typer.
5 Pupil surveyors.
2 Clerks.

The sphere of operations of the party lay in Madras, Mysore and Coorg. The work consisted of survey on the 1-inch, $1\frac{1}{2}$-inch and 2-inch scales, revision survey on the 1-inch and $1\frac{1}{2}$-inch scales and triangulation.

The nature of the country was extremely varied, from the low, undulating and intricate country on the west coast, consisting of cultivated valleys fringed with dense groves of palms and dotted with innumerable huts, to the densely wooded foot hills and bold crests of the Western Ghāts and further east the undulating Mysore plateau.

The field season started on the 26th November 1911 and closed on the 29th May 1912. The head-quarters of the party was located at Mangalore.

The health of the party was good during the field season with some exceptions. The health during recess has been fair.

The area surveyed fell in the South Kanara and Malabar districts of Madras, in the Hassan and Kadūr districts of Mysore and in the Pādinālknād tāluk of Coorg. The work was divided into three camps each under a provincial officer.

Sheets 48 $\frac{L}{13,\ 14,\ 15}$ and 48 $\frac{P}{1,\ 2,\ 3,\ 5,\ 6,\ 7,\ 9}$, amounting to 2,258 square miles, were completely surveyed and a portion of sheet 48 $\frac{P}{8}$, amounting to 89 square miles, was also surveyed, making a total of 2,347 square miles.

Triangulation.—Triangulation was carried out by one provincial officer in the Salem and North Arcot districts of Madras and in the Kolār district of Mysore. Sheets 57 $\frac{L}{1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7,\ 8}$ amounting to 2,321 square miles were completed. The country triangulated is for the most part open, flat and cultivated excepting where the Mysore plateau falls away to the plains where there are forest-clad hills.

Recess duties.—The fair mapping of the coast sheets is arduous owing to their extremely intricate nature. The fair mapping was divided into three drawing sections with an average of three sheets each. Sheets 48 $\frac{L}{14,\ 15}$ were completed during the year under report, and it is hoped that the remainder of the sheets surveyed, *viz.*, sheets 48 $\frac{L}{13}$ and 48 $\frac{P}{1,\ 2,\ 3,\ 5,\ 6,\ 7,\ 9}$, will be submitted by the middle of November 1912.

The computation of the triangulation of sheets 57 $\frac{L}{1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7,\ 8}$ has been completed and there are no arrears of computations. One triangulation chart 48 K has been practically completed and will be submitted before the end of the recess. It has been impossible to bring the triangulation charts of the party up to date as there has been no officer available for the work; the preparations for the field season having taken up a good deal of time during the recess owing to the large number of 4-inch forest sheets which have had to be reduced and inked up, etc.

NOTE.—A new method of obtaining blue prints for fair mapping has been tried and found successful. A sheet was projected on drawing paper on the 1-inch scale. The plane-table sections were traced and, the correct graticule having first been traced from the projected sheet, the necessary adjustments were made to eliminate distortion. The traces were then mounted on the projected sheet, the whole was enlarged by photography to the 1½-inch scale and two blue prints were obtained for fair mapping, one for outline and one for hills. Separate traces are usually made of each 5 minute square but if convenient they can be made of larger areas. This new method has advantages over the method hitherto employed which is somewhat similar except that the traces are made from 1½-inch enlargements of the plane-table sections, the traces are mounted on a 1½-inch projected sheet and the blue prints are obtained by vandyking. The advantages of the new method are that the amount of photography is reduced, the vandyking is done away with, the resulting blue prints being obtained by photography are superior to those obtained by vandyking, the traces can be commenced sooner and the tracing is easier and quicker as there is less area to trace and the plane-table sections being in colour are much clearer than the 1½-inch enlargements. An additional advantage is that the plane-table sections have not to be photographed, and can consequently be completely coloured up in the field. A disadvantage is that the traces have to be more carefully and finely drawn than those on the 1½-inch scale, and probably the work could not be satisfactorily done by inferior draftsmen, for this reason it may not always be possible to employ the new method for every sheet.

If a plane-table section be suitable for enlargement for the direct mapping process in every respect except that it is not a complete sheet it is probable that, by making traces of the incomplete portion of the sheet, mounting the traces on the plane-table section and then enlarging the plane-table section by photography to the 1½-inch scale, good blue prints of the whole sheet could be obtained for fair mapping. In this case, of course, the plane-table section should not be completely coloured up in the field. The traces should only be lightly mounted at their corners and could be subsequently removed from the plane-table section.

No. 8 PARTY (MADRAS).

BY CAPTAIN C. M. BROWNE, D.S.O., R.E.

PERSONNEL.

Imperial Officers.

Captain C. M. Browne, D.S.O., R.E., in charge.
Captain R. Foster, I. A.

Provincial Officers.

Mr. R. Waller-Senior to 28th January 1912.
Mr. W. F. E. Adams.
Mr. E. J. Biggie to 4th June 1912.
Mr. S. F. Norman.
Mr. J. H. Williams from 8th June 1912.
Mr. M. Mahadeva Mudaliar.
Mr. Balaji Dhondiba.
Mr. M. S. Ganesa Aiyar.

Upper Subordinate Service.

Mr. Anantarao Dhondiba, R.S.

Lower Subordinate Service.

21 Surveyors.
1 Soldier surveyor.
1 Draftsman.
1 Traverser.
7 Pupil surveyors.
2 Clerks.
1 Sub-assistant surgeon.

The work carried out by the party was of the same nature and in continuation of the previous year and covered parts of the Malabar and Coimbatore districts of Madras and the Travancore and Cochin States in Madras. The work comprised surveys on the 1-inch, $1\frac{1}{2}$-inch and 2-inch scales and traversing along the coast for the $1\frac{1}{2}$-inch scale.

The Pambiyār catchment area forms part of the Pandalam Hills and except where explored by the Public Works Department of Madras, it was practically unknown and absolutely uninhabited. The area is covered with ever-green forest with dense undergrowth, there are little or no means of communication and transport and labour are extremely hard to obtain as no men from the low country will go into this area, few hill-men were obtained, and all supplies had to be imported. The surveyors and their squads suffered from malarial fever during the time they remained in this locality. Of the rest of the country in the main part of the programme, the plains' portion near the coast consisted of flat country intersected by numerous streams and back-waters, it is covered with dense cocoanut plantations or is under paddy cultivation and it is studded with innumerable scattered habitations, and the hilly portion consisted of forest which becomes denser as the elevation increases with the exception that some of the hill tops are grassy but, as in many cases the grass is very thick and high, from a surveyor's point of view, it is equivalent to dense jungle.

The party left Bangalore on the 13th November 1911 arriving at Alwaye and Ernākulam on the evening of the next day. The experiment of taking a special train was a great success, not only was there a direct saving of money to Government but, as it arrived with all its equipment, etc., the party could take the field without any delay. No advance party was needed and drawing went on with the full strength of the party up to within two days of leaving for the field. The head-quarters of the party was located at Pīrmed (Peermade) in the Travancore State until the 14th May 1912 when it returned to Bangalore. Field work closed with one exception in the last week of May and the recess season was opened in June.

The health of the party was on the whole good, considering the country in which it was working, until towards the end of the season when most of the members of the party suffered in one way or another. Two *khalāsis* died.

Topography.—The work was distributed among camps as follows :—

Camp No. 1 was under Mr. Waller-Senior until the 28th January 1912 and from then until the end of the season under Mr. Biggie. The camp was employed on the survey of sheets $58\frac{B}{12,\ 16}$ in the Cochin and Travancore States and in a small portion of the Coimbatore district. The whole area was surveyed on the 1-inch scale except the 8·5 square miles of the Anaimalai reserved

forest which formed the small portion of the Coimbatore district above mentioned and which was surveyed on the 2-inch scale as the old 4-inch forest map was acknowledged to be inaccurate.

Camp No. 2 was under Mr. Adams and undertook the survey on the $1\frac{1}{2}$-inch scale of sheets 58 $\frac{C}{1, 5}$ in the Malabar district and in the Cochin and Travancore States.

Camp No. 3 was under the charge of Mr. Balaji Dhondiba and completed the survey on the 1-inch scale of sheets 58 $\frac{C}{9, 13}$ in the Travancore State and of the portion remaining unfinished from last year in sheet 58 $\frac{B}{11}$ in the Cochin State.

Camp No. 4 was under the charge of Mr. Anantarao Dhondiba, it completed the survey on the 2-inch scale of the Pambiyār catchment area which falls entirely in the Travancore State and then worked on the 1-inch scale in sheet 58 $\frac{C}{14}$ in the Travancore State.

There is a comparative absence of village sites in the Malabar district and in the Cochin and Travancore States in spite of the density of their population which live for the most part in scattered huts. As it is impossible to show all these huts on the $\frac{1}{4}$-inch scale owing to their numbers, the more important and prominent ones are now distinguished at the time of survey with a view to showing them, if possible, on the degree sheets, this was not done previously to 1910-11 and in consequence, at the close of the field work this season, the whole of the 1-inch sheets in degree sheets 49M and 49N were gone over on the ground and the huts, for showing on the $\frac{1}{4}$-inch scale, were marked on the 1-inch sheets which were issued to the surveyors for that purpose; the difficulty was not thought of until after the sheets had been surveyed and any selection, except on the ground, would possibly have resulted in the omission of large masonry houses, etc., whilst merely grass huts might have been shown.

Sheets 58 $\frac{B}{12, 16}$ and 58 $\frac{C}{1, 5, 9, 13}$ were entirely surveyed, the survey of sheet 58 $\frac{B}{11}$ was completed and sheets 58 $\frac{C}{14}$ and 58 $\frac{G}{3}$ were partially surveyed; the portion completed in 58 $\frac{G}{3}$ comprised the survey of the Pambiyār catchment area which completes the material for the special combined map on the 2-inch scale of the Periyār and Pambiyār catchment areas. 1,202 square miles were surveyed on the 1-inch scale, 282 square miles on the $1\frac{1}{2}$-inch scale and 66 square miles on the 2-inch scale. The total area surveyed was 1,550 square miles and is greater than that of last year by 263 square miles. The extraordinary difficulty of the country from a surveying point of view made it impossible for any of the surveyors to turn out anything but a small portion of their usual work.

Triangulation.—No new triangulation was undertaken there being more than sufficient for the next two years.

Traversing.—Traverses, with branch traverses, were run along the coast from Cochin to Alleppey and thence to Quilon to give points to plane-tablers in sheets 58 $\frac{C}{1, 5, 6, 7}$, a total of 182 linear miles. Along the coast in these sheets the country is flat and low lying, covered with palm groves and intersected by streams, the triangulation could not approach near enough to pick up a sufficient number of points for the plane-tablers and hence the necessity of traversing.

Recess duties.—In fair mapping good progress was made, and, at the close of the recess, there will be no arrears except about 12 square miles in sheet

58 $\frac{B}{13}$, where the discovery of a serious inaccuracy makes it impossible to complete the fair drawing of the sheet until the matter has been settled on the ground. The programme carried out was sheets 58 $\frac{B}{8, 11, 16}$ and 58 $\frac{C}{1, 5, 9, 13}$, and sheet 58 $\frac{B}{13}$ as above mentioned, completed except for a small portion. Sheet 58 $\frac{C}{1}$ was drawn as an outrigger to sheet 58 $\frac{C}{5}$. The whole area comes to 1,447 square miles. In addition to the above the Ootacamund Hunt Map on the 3-inch scale is in hand and will, it is hoped, be completed by the end of the recess.

Triangulation charts 49 M, 49 N, 58 A and 58 B were completed this year and 58 C is almost complete, these are all arrears of long standing.

NOTE.—Last year, as reported, the use of mill boards did not prove very successful and this year the experiment was tried of pasting a sheet of rag-litho paper over the boards, which was a success, the measurements gave very little difference and the advantage of being able to take off the section and roll it up, if desired, is great. In the coming field season most of the boards will be mounted in this way.

EASTERN CIRCLE.

(*Vide* Index Maps 3 and 6.)

This circle remained under the superintendence of Brevet-Colonel G. B. Hodgson throughout the year and was strengthened by the addition of No. 9 Party which was transferred from the Northern Circle. Last year the Circle Office and Nos. 9 and 12 Parties were accommodated in the offices of the Assam Secretariat at Shillong which had become available owing to the offices of the local Government having been removed to Dacca. On the 1st April 1912, however, Assam having again been formed into a separate province, the buildings at Shillong were again required by the local Government and four private houses were rented for the Survey offices at a cost of Rs. 445 per mensem.

No. 9 PARTY (BIHĀR AND ORISSA).

BY COL. G. B. HODGSON, I.A.

No. 9 Party commenced work in the Singhbhum district and Orissa Feudatory States triangulating an area of 7,559 square miles in sheets 73 F and B and 72 L and surveying in detail on the 1-inch and 2-inch scales 2,596 square miles.

PERSONNEL.

Imperial Officers.

Major G. A. Beazeley, R.E., in charge up to 12th August 1912.
Captain R. H. Phillimore, R.E., in charge from 13th August 1912.

Provincial Officers.

Mr. Dhani Ram.
Mr. B. C. Newland.
Mr. F. Byrne.
Mr. A. K. Mitra.
Mr. W. P. Hales.
Mr. D. N. Banarji.

Upper Subordinate Service.

Mr. Dalbir Rai.
Mr. M. R. Mazumdar.
Mr. R. D. Thaplyal.

Lower Subordinate Service.

28 Surveyors.
1 Traverser.
4 Computers.
5 Soldier surveyors under training.

The field season commenced on the 15th October 1911 when the first section of the party left recess quarters at Shillong and field work continued until the 13th June 1912 owing to the backward state of the work, though some members of the party returned to Shillong about the middle of May.

Topography.—The greater part of the detail survey consisted of a supplementary survey of the maps compiled from the 16-inch cadastral survey which was carried out partly in seasons 1895 to 1897 and 1902 to 1904.

The following 8 sheets were completely surveyed, Nos. 73 $\frac{F}{4, 9, 10, 11, 13, 14, 15, 16}$ covering an area of only 2,199 square miles out of the total of 2,596 surveyed in detail.

Major Beazeley says it was impossible to separate the cost of the 3 classes of 1-inch survey as so many changes took place amongst the surveyors owing to sickness and other causes and a cost-rate is not of any value owing to its being the first season in country of a totally different nature to what the surveyors had been hitherto accustomed. The outturn of detail survey and cost-rates are given in the tables on pages 36 and 38. The revision survey was a revision of 4-inch forest maps.

Triangulation.—The outturn of triangulation has been very large as it was hoped that with the assistance of the excellent maps of the cadastral survey, the outturn of the party would be at least a whole degree sheet and that in future 2 degree sheets would be surveyed each season. This expectation

does not appear at all likely to be realised, the outturn this season being particularly small. This, however, may be ascribed to its being the first season in a new province and to the very different nature of the country to what the surveyors had been accustomed to in the Punjab, where it is open and dry. Here the country is heavily wooded excepting in the cultivated valleys and a good deal of rain was experienced during the field season.

It has now been decided that the Native States are to be surveyed on the $\frac{1}{2}$-inch scale, and a considerable improvement in the outturn is expected next season when sheet 73F will be completed and probably the eastern half of sheet 73B.

The cost-rate of the triangulation is low as the whole area had been triangulated before, and it was only necessary to re-observe at the old stations to fix fresh stations and points, only 2 zeros being used; also out of the 4 observers, 2 were surveyors.

Traversing.—The traversing was all forest boundary traversing. The cost-rate is very high, partly, owing to its being supervised for part of the field season by Lieutenant Huddleston who also had charge of the computations during recess and partly, to there being no trained traversers in the party. Surveyors had to be taught the work and much of it had to be re-done.

Recess duties.—The sheets surveyed, (*viz.*:— $73\,\frac{F}{4, 9, 10, 11, 13, 14, 15, 16}$), were all fair mapped and forwarded to the Circle office before the party took the field again.

The cost-rate of the mapping is high as 4 officers of the Provincial Service and 3 of the Upper Subordinate Service were employed on drawing.

Notes on the mounting of Bristol boards and of drawing paper on plane-tables for the field.

BY CAPTAIN R. H. PHILLIMORE, R.E.

(1) The distortion of field sections is a great hindrance to rapid fair mapping, and laborious processes have to be introduced for its elimination.

(2) When a field section remains true to projection, the north and south lines having expanded or contracted equally with the east and west lines, then it can be so enlarged or reduced by photography that its graticule exactly fits the truly projected fair sheets. Detail may then either be printed direct on to the fair sheet or transferred straight from the photographic prints to the fair sheet.

(3) When, however, the plane-table section has expanded or contracted more in one direction than in the other, the photographic enlargements or reductions will remain distorted ; and cannot be directly transferred to the fair sheet.

The processes of transferring all detail by specially prepared traces during which the distortion is eliminated, occupy from five to six weeks for each fair map. Special traces have to be prepared for the hill sheet as well as for the outline sheet.

It is to save this expenditure of labour in fair mapping that endeavours are being made to mount the field section on the plane-table so that it shall not distort.

(4) Any paper or thin board which is pasted firmly down on a wooden plane-table over its whole area will expand and contract with the plane-table. The wooden plane-table expands and contracts more across the grain than it does with the grain ; hence the distortion of any graticule drawn on the mounted paper.

The writer has tried mounting Bristol boards by pasting them firmly down on the plane-table, and the graticules were found to distort just as much as with drawing paper.

(5) To mount either drawing paper on Bristol boards by pasting them firmly down along the edges and leaving them free otherwise, results at once in "cockling," for paper does not naturally expand or contract equally with the wooden plane-table. The paper is more absorbent than the plane-table, and it is also more readily affected by the direct rays of the sun.

(6) During season 1911-12, Major Beazeley, R.E., in No. 9 Party used a special paper mounted on stiff canvas. This paper was pasted on the plane-tables round the edges only, and it was hoped that would not cockle so much as ordinary drawing paper, being less absorbent.

It did cockle a good deal though ; the paper was of poor quality, and would not stand erasure and the resulting field sections were all very dirty and many almost illegible.

But there was no distortion of graticule at all ; the photographic enlargements exactly fitted the true projections on the fair sheets. Sufficient blue prints of the enlargements were obtained for :—

(1) Direct transfer of outline detail to outline sheet.
(2) Entering up names for typing.
(3) Direct transfer of hill detail to hill fair sheet.

No special adjusted traces had to be prepared.

(7) In order to get the advantages of this direct mapping and transferring, and to avoid the very objectionable cockling, the field sections of No. 9 Party have been mounted this season by pasting one edge of the paper or Bristol board firmly to the plane-table and leaving the other three edges lightly held down by cloth but free to expand or contract.

(8) No. 9 Party is carrying out supplementary survey over an area that has been recently surveyed cadastrally. The 1-inch reductions of cadastral maps are supplied printed in grey on 210 lbs. drawing paper mounted on cloth. Bristol boards are being used for some field sections.

Both Bristol boards and the cloth mounted drawing paper are being mounted in the following way :—

The field section is fastened firmly along one long edge of the plane-table by a strip of cloth pasted firmly round the edge of the board.

The other three sides of the field section are cut so as to leave a half-inch margin of plane-table round them.

Strips of cloth are then pasted along these three edges, along the upper surface of the field section and along the underside of the plane-table only. The cloth must not adhere to the plane-table at all along the half-inch interval between the edge of the field section and the edge of the plane-table. The cloth is stretched tight when mounting and the field section must not be wetted.

If the atmosphere now begins to get dry, the wooden plane-table shrinks across the grain more than the field section does and the cloth round the three free edges becomes slack.

There is no cockling in the paper or the Bristol board as they are both stiffer than the cloth which binds the edges.

(9) In actual practice some of the field sections were allowed to get stuck here and there along the three edges which were supposed to be free, and cockling has followed. The edges have since been released, and the drawing paper settled flat at once, but it is impossible to get all the cockle out of the Bristol boards. Where the edges had been left properly free to start with, the Bristol boards have not cockled at all.

(10) As the plane-table contracts during the dry weather, the field sections may get inconveniently loose along the free edges. Surveyors have been supplied with adhesive paper, such as is used in repairing music, etc., strips of which can be fastened at intervals round the edges.

(11) Bristol boards or cloth mounted drawing paper are more suitable than plain drawing paper, as they are heavier and stiffer and lie more closely to the plane-table.

The writer has worked on a board so mounted and experienced no inconvenience from the slight play between paper and board.

This method cannot, of course, be pronounced successful till the close of field season, but so far it has worked as expected, except for the accidental dropping of paste along edges which were not supposed to be pasted. The officer superintending had not fully realised the importance of this point.

No. 10 PARTY (UPPER BURMA).

BY COL. G. B. HODGSON, I.A.

The party continued work in the Kathā, Bhamo and Myitkyinā districts of Upper Burma. The country under detail survey was mountainous, the valleys being deep and densely wooded, and consequently the survey had to be done almost entirely by plane-table traversing. The altitude varied from 300 feet on the Irrawaddy river to over 7,000 feet in the highest hills.

PERSONNEL.

Imperial Officers.

Brevet-Major E. T. Rich, R.E., in charge.
Lieutenant W. E. Perry, R. E.

Provincial Officers.

Mr. O. D. Smart.
Mr. P. Williams.
Mr. W. G. Jarbo.
Mr. V. W. Morton.
Mr. Asmatullah Khan, K.S.
Mr. W. H. Strong.
Mr. C. B. Sexton.
Mr. Hayat Muhammad, K.S.
Mr. B. C. H. Collins.

Lower Subordinate Service.

17 Surveyors.
2 Traversers.
3 Computers.

The recess office closed on 11th November 1911 and re-opened on the 27th May 1912 giving a field season of just five months.

The programme of both triangulation and detail survey was not completed as Lieutenant Perry and 4 of the best Surveyors of the party were attached to the North Burma and Laukhaung missions and one Surveyor remained sick throughout the field season. An outbreak of cholera amongst the *khalāsis* while they were going up the Irrawaddy river by steamer to join the party for the field season, also contributed to the non-completion of the programme, as the *khalāsis* were detained in a segregation camp for over a fortnight during which work was practically at a stand-still, although the surveyors proceeded to their various destinations and started work with the aid of men supplied from the villages.

One of the triangulators was also delayed by the failure of his mule transport, (which comes from China), to arrive at the proper time owing to the political unrest in China.

Two Surveyors and one officer of the Upper Subordinate Service were attached to political missions in North Burma.

The section of this party hitherto occupied in training officers of the Burma Land Records Department was transferred to the Burma Government, from the 1st April 1912.

Topography.—The party carried out the detail survey on the 1-inch and 2-inch scales of 2,689 square miles; 71 miles of trans-frontier sketch survey were also carried out.

The following 12 sheets were completely surveyed:— Nos. $92\frac{D}{7,8,11,12,14,15,16}$, $92\frac{H}{5,9,13}$, up to the China boundary and $93\frac{E}{1}$.

The revision survey consisted of the revision of the maps of forests that had been previously surveyed on the 4-inch scale. The hills had to be contoured as they had not been contoured in the old maps.

Details of the forests surveyed will be found in the General Report Volume for 1911-12.

The cost-rate of the 2-inch forest survey this season is much lower than it was last year when it was very high owing to the lack of demarcation, some of the reserves surveyed then not having been demarcated as they had only just been reserved.

Triangulation and Traversing.—2,336 square miles were triangulated and 500 square miles were traversed, making a total of 4,500 square miles prepared in advance.

The combined cost-rate per square mile for triangulation and traversing for 1-inch detail survey is Rs. 10·4, the cost of the traversing alone being Rs. 26·4 per square mile.

Recess duties.—The whole of the mapping was finished and forwarded to head-quarters before the party took the field again.

The cost of mapping is very high, but Major Rich is unable to give any special reason for it.

No. 11 PARTY (LOWER BURMA).

BY COL. G. B. HODGSON, I.A.

The party continued work in Karenni and the Salween district of Lower Burma.

PERSONNEL.

Imperial Officers.

Major E. A. Tandy, R.E., in charge to 4th May 1912.
Captain L. G. Crosthwait, I.A., in charge from 5th May 1912.

Provincial Officers.

Mr. C. Litchfield.
Mr. T. P. Dewar.
Mr. A. A. Graham.
Mr. H. St. J. Kenny.
Mr. A. J. Booth.
Mr. R. M. Wyatt.

Upper Subordinate Service.

Mr. Lachman Daji Jadu, R.B.

Lower Subordinate Service.

21 Surveyors.
3 Pupils.
1 Soldier surveyor under training.

The country surveyed in detail consisted of part of the watershed of the Salween river and its tributary the Nam Pawn, and was not difficult to survey. Inspecting officers, however, found some difficulty in getting about, as the tracks were almost impossible for mule transport with which the party was equipped. The hills were steep and rocky but only lightly wooded.

The field season, as usual in this party, was a short one owing to the distance of the field of operations from the railway. The party left recess quarters towards the end of November and returned thereto early in May with the exception of 2 Surveyors who remained in the field till the 20th June to complete the programme of 2-inch forest survey which had been delayed owing to the illness of one of the Surveyors. Three Surveyors were attached to the North Burma mission and one to the Abor expedition; one was dismissed at the commencement of the season and one died at the end of the field season, during almost the whole of which he was unable to work.

Topography.—The programme of 1-inch and 2-inch surveys was completed but that of the ¼-inch survey was not. This was partly due to one of the Surveyors having fallen sick and having to return to recess quarters before the end of the field season and Mr. Lachman Jadu, under whose supervision it was being carried out, and who was also engaged on detail survey himself, had to complete the 2-inch forest survey in sheet 94G owing to the illness of another Surveyor.

The outturn was 2,010 square miles of 1-inch and 2-inch detail survey in sheet 94E and 1,628 square miles of ¼-inch survey in sheet 94G.

The cost-rate of the 1-inch survey is considerably higher than that of last season owing to the area surveyed being much smaller.

Triangulation.—The party carried out 3,950 square miles of triangulation for 1-inch survey in the Tavoy and Amherst districts and 530 square miles for ¼-inch survey in the Salween district.

The cost-rate of the triangulation (in contradistinction to that of the detail survey mentioned above), is much lower owing to the large area triangulated this season, although the country was difficult, being densely wooded. A series of G. T. Survey triangulation passes over the area triangulated.

Recess duties.—The following 7 sheets were entirely surveyed and mapped :— 94 $\frac{E}{1, 3, 4, 5, 6, 7, 8}$. The mapping of the $\frac{1}{4}$-inch work in 94G was only completed in outline as the sheet will have to be completed to graticule limits from old surveys and this will be done in the circle drawing office.

No. 12 PARTY (ASSAM).

BY COL. G. B. HODGSON, I.A.

No. 12 Party continued to work in Assam and triangulated and traversed 3,256 square miles and surveyed in detail on the 1-inch and 2-inch scales, 3,359 square miles in the Khāsi and Jaintia Hills and Kāmrūp districts.

PERSONNEL.

Imperial Officers.

Captain R. H. Phillimore, R.E., in charge to 12th August 1912.
Lieutenant G. F. T. Oakes, R.E., in charge from 13th August 1912.

Provincial Officers.

Mr. W. Skilling.
Mr. Pramadaranjan Ray.
Mr. E. M. Kenny.
Mr. Amjad Ali.
Mr. L. Williams.
Mr. P. C. Mitra.
Mr. H. H. Creed.

Upper Subordinate Service.

Mr. Nanak Chand Puri.

Lower Subordinate Service.

27 Surveyors.
3 Traversers.
3 Computers.
3 Soldier surveyors.
1 Pupil surveyor under training.

Lieutenant Oakes was attached to the Abor expedition throughout the field season, and 3 surveyors were attached to various political missions for part of the field season and one was on sick leave the whole season, consequently neither the programme of triangulation nor that of detail survey was completed, though the outturn of detail survey only fell short of the programme by one sheet.

In his interesting report Captain Phillimore says :—

"During season 1910-11 the party had been surveying the open plateau of the Khāsi hills with its declivities and abrupt descent in the Surma valley southwards. This season only 2 sheets lay in the open ground on the plateau ; some 3 or 4 sheets were occupied with the wooded spurs which wind northwards to the Brahmapūtra valley and the remainder of the work lay in the swampy plain of the Brahmapūtra, mostly in the Kāmrūp district. The northward falling spurs of the Khāsi hills are heavily wooded, mainly with *sāl* forest, much of which is reserved by the Forest Department. Undergrowth is very heavy but the hills sides are steep and fixings could always be obtained with a certain amount of clearing. In the neighbourhood of villages there were considerable patches of ground already cleared. Chains were taken from the Surveyors who had hitherto always worked entirely with chains so their progress was slow, but they should be really useful in the hills another season. Roads and villages were not frequent, the few inhabitants being Gāros and Mikirs who were more friendly than either Khāsis or Assamese and were ready to supply what they could in the way of labour and provisions."

Describing the Brahmapūtra valley in which the party will mainly be working for the next 5 years, Captain Phillimore says :—

"For several miles to the south of the river, the ground lies very low and is mostly under water during the rains. When the surveyors took the field in November, they had to confine work to the neighbourhood of the Gauhati-Goālpāra trunk road which hugs the foot of the hills, paddy was still being cut and the fields were not passable till late in December. Work was then extended over the populated areas where the country was fairly open and paths available. It was not till the end of February that the surveyors were able to make much headway in the swampy ground towards the river ; this was covered with dense *khagra* grass growing to 20 feet in height. Men

were very nervous at first about entering this ground, fearing tigers, elephants and buffalo: however, no incidents of note occurred. As the season advanced, the swamps dried, the tall grass was burnt and villagers came in to clear the fields."

"There was very little detail to be surveyed in this area. Streams were found to have altered but little since the time of the old Revenue Survey. The plane-tablers ran chain lines here and there through the grass, advancing perhaps a mile in a day, with four or five men to cut a passage. Sometimes they met with a slight depression holding water, sometimes a stream shown on the old map. This was followed up for a short distance and if the old survey was found right at points 2 miles apart the interval between was accepted. The Brahmapūtra river itself was not difficult to survey. It here spreads out to a width of 5 miles or more, in constantly shifting channels; the river banks, islands and channels had completely changed since the cadastral maps had been prepared, so this ground should rightly have been classed as original survey. The rise and fall of the river is from 30 to 35 feet; flood level at Gauhati being about 160 feet above the sea. Country boats were not obtained at all points as there is so much waste-land along the banks and the surveyors had to hire boats for a few days at a time and were often held up for lack of them."

"Here and there along the river, small rocky hills formed useful points for the plane-tablers, who were able to carry on with interpolated fixings from these and other points fixed by triangulation south of the river. North of the river, work was carried on entirely from traverse points. Across the river there are several densely populated districts in north Kāmrūp clustered round important centres such as Hajo, Nalbari, Barpeta. The villages are surrounded by bamboo clumps and gardens, the intervening ground is continuously cultivated, distant views were impossible and work was carried out entirely by chaining. In other parts there are extensive wastes of swampy land. To the east of Barpeta there is a stretch of 100 miles of such ground and it is interesting to note that in the old Revenue Survey maps this is shown as thickly populated so something serious must have affected the drainage and this is generally said to have been the great earthquake of 1897."

"As the ground rises gradually towards the Bhutān hills, marshy land is less extensive and forests begin to appear; the wide stretches of grass land are full of game till the grass dies down or is burnt. The rivers that break out from the Bhutān hills are continually changing their courses across the valley where they flow in shallow channels and spread out into small streams. During the rains new channels form and bring down floods to wash away villages and fields. The Pagladiya is the most unruly of these rivers and efforts are still made to train it into a straight course to the Brahmapūtra. The shifting of rivers causes the shifting of villages and the maps of Kāmrūp district will always require more frequent revision than others. There are only a few roads along which carts can be taken all the year round but during the dry months, January, February and March carts can be used more freely. They can only be obtained at the big villages however and one or two days' notice has always to be given. Coolies are obtainable with the greatest difficulty and never in greater numbers than half a dozen at a time. Elephants are the only form of transport that can be taken at any time up to the foot of the Bhutān hills or into the swampy ground near the river, and all officers in the party were much hampered by lack of elephant transport."

"South of the Brahmapūtra in the Nowgong district, the country is very swampy and communications are most meagre. The hills along the south margin sheet of 83B are fairly thickly wooded and villages are scarce and elephant transport is most necessary in this area."

"Considerable difficulty was experienced throughout the valley in obtaining supplies and labour. *Mauzadars* and head-men were on the whole quite polite but had little authority over the villagers who strongly resented being called out either for jungle clearing or carrying loads. There are many dispensaries with subordinate medical officers at different centres in the Kāmrūp district and the surveyors made considerable use of them."

"The men working in the Khāsi hills left Shillong on the 3rd November 1911, and were all at work by the 10th. The remainder of the party assembled at Gauhati, the field head-quarters, on the 13th November and the last surveyor started work in the plains by the 25th of that month. It is impossible to start field work earlier in the Brahmapūtra valley as the greater part is under water till then. The survey in the Khāsi plateau was finished during March when the surveyors were moved down into the low country. No rain fell in the valley till quite the end of March and the atmosphere became very thick with smoke haze; plane-tablers lost many days through not being able to see points 3 miles distant. When rain came at last, it was very persistent and over 10 inches fell during April (nearly double the normal fall), and several surveyors fell sick. The reduced programme was completed by the end of April and office re-opened at Shillong on the 6th May."

"There were 3,660 working days out of a total of 5,130 days. The 1,470 non-working days were not spread evenly through the season; they include the periods of marching to and from the field and lengthy periods of sickness of a few individuals."

Topography.—The following sheets were completely surveyed :—Nos. 78 $\frac{N}{1, 2, 3, 4, 5, 6, 7, 8, 12}$ and 78 $\frac{O}{1, 2, 5, 6, 9}$ and the fair mapping was completed before the end of the year.

Regarding the nature of the season's work Captain Phillimore says : "The work may be classified as follows :—

(*a*) Original survey on the 2-inch scale. North Kāmrūp Forest reserve.

(*b*) Original survey on the 1-inch scale. Mostly in the Khāsi Hills; a large area of flat ground in the valley was also included under this head, being uninhabited land surveyed prior to 1875 on the 4-inch scale by the old Revenue Survey.

(*c*) Supplementary survey on the 1-inch scale in the Kāmrūp district of ground surveyed cadastrally on the 16-inch scale between 1883 and 1897.

(*d*) Revision survey on the 1-inch scale of reserved forests already surveyed on the 4-inch scale."

"The work of the 4-inch Revenue Survey and of the 16-inch Cadastral Survey had been published in 1-inch maps: prints of these were obtained on bank-post paper and such detail as was useful was transferred to the plane-table sections by 5 minute squares. Main roads and village trijunctions proved the most useful items of the old surveys. Here and there streams were found following their old courses and in such places the old surveys were found very accurate, but over the greater part of the Brahmapūtra valley, streams and other water forms have entirely changed during the last 15 years or so."

"The older Revenue work which had been classed for original survey was found quite as useful as the later cadastral surveys."

There is nothing to remark about the cost-rates except that that of the 2-inch forest survey is a good deal lower than last year's which is due to easier ground. There was not much detail and forest was only very dense along the streams. The rates for 1-inch original and supplementary survey differ from last year's, the total for the two classes being exactly the same, so that the difference is probably due to differences of classification.

Triangulation.—"The triangulation computations worked out quite satisfactorily, though very discrepant angles were obtained at one station. This was a bench-mark on the trunk road and the discrepancies appear to have been due to excessive refraction. As the work ran along a G. T. S. series and was connected with 7 of its stations, a fairly high standard of accuracy was maintained. One side common to Lieutenant Oakes' work of season 1909-10 was computed and one common to Mr. Williams' work of last season. In the former case the difference in length was 1 foot and in the latter 2 feet, while the differences in height at the former 2 stations were —8·0 feet and —7·4 feet respectively. The differences in latitude at the former 2 stations were 0″·10 and 0″·12 and in longitude 0″·09 and 0″·04, while at the latter they were 0″·02 and 0″·01 and 0″·03 and 0″·00 respectively. As Mr. Williams' work was based on the G. T. S. series, as was Mr. Mitra's, small differences were to be expected, but Lieutenant Oakes' work was based on the revisionary triangulation in the Khāsi Hills carried out by Mr. Bond after the earthquake of 1897 and appreciable discrepancies were expected. Last season's work indicated that Mr. Bond's revisionary heights were from 5 to 7 feet too high (*vide* page 19 of last year's Records), and this is indicated again this year by Mr. Mitra's two heights being 7 and 8 feet lower than Lieutenant Oakes'."

Recess duties.—All the sheets surveyed were fair mapped with the exception of sheet 78 $\frac{N}{5}$ which requires some revision, which will be done early next field season. Five draftsmen of the circle drawing office were lent to the party during recess to assist in the mapping. Special attention was paid during recess to training promising Surveyors in drawing, but the results were somewhat disappointing.

THE LEBONG CANTONMENT SURVEY.

BY LIEUTENANT J. A. FIELD, R.E.

The point of origin of the cantonment survey of Lebong and the municipal survey of Darjeeling is Observatory Hill G. T. H. S., height 7,162 feet. The scale of survey is 20 inches=1 mile.

The Lebong survey starts from one of the main traverses of the Darjeeling municipal survey and its operations are contained in two complete circuits and a portion of a third one which is common to both the municipal and cantonment surveys.

These main traverses are run along the roads which surround the cantonment, and are closed up, and the errors adjusted in the usual way.

The angular error was found to be very small, but a greater margin of linear error had to be allowed, owing to the difficulty of chaining accurately down steep slopes. In some cases errors of 1 link in $2\frac{1}{2}$ chains had to be passed, while in the plains no errors greater than 1 link in 10 chains are permissible.

The experiment was tried of remeasuring one of the lines several times, but each measurement gave a different result, showing that the differences were due entirely to the difficulty of the work and not to faulty chaining. In such surveys no hard and fast rule can be laid down as to the margin of error permissible—every case has to be judged separately on its merits.

In this hill survey, 100 feet tapes are used to a great extent instead of chains. In "cutting" when measuring down a hill, a tape does not sag like a heavy chain does; and it is also convenient sometimes when "cutting", to be able to take a measurement of less than 1 link. Another advantage which the tape possesses is, that when traversing over broken and difficult country, gaps or nullahs are often met with over 1 chain wide but less than $1\frac{1}{2}$ chains. In such cases the distance can be measured with the 100 feet tape, whereas, if only the 66 feet chain were available the traverse would have to be taken round the obstacle, meaning extra stations and extra labour.

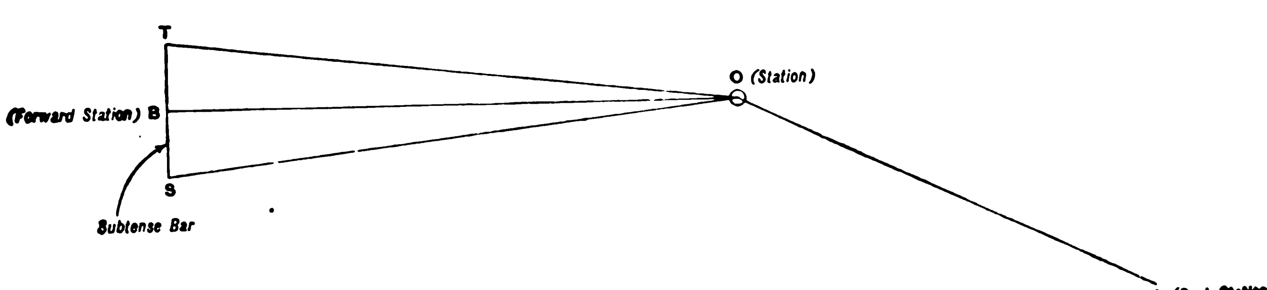
The tapes have to be continually tested against the traverser's standard chain. Each man ordinarily has 3 chains ;—one of which is used for running the main traverse, another for taking offsets, while the third is kept in reserve as a standard.

All the chains were obtained from Hazāribagh, and tested before despatch between two marks laid down on the verandah of the Survey Office there.

Subtense methods are considerably used in running these traverses. They prove useful in measuring along main circuits over bad ground, where it is difficult to chain, and in some cases a subtense line of as short as 3 chains was measured.

Another way in which subtense work comes in very useful is for measuring across from one side of a circuit to the other; this gives a very good check on the work, and localises any errors that there may be.

It is of interest to note that the method laid down by Colonel Tanner in his note on the subtense bar is not followed in its entirety. His procedure was to plumb the subtense bar on its stand exactly on the station O.



He first observed the angle A O S, and then the angle S OT to give the distance. To obtain the circuit angle, the angle S O T was halved, and added to AOS, giving the angle AOB. The objection to this is that such a lot of time is spent plumbing the subtense bar accurately.

The method adopted in the Lebong survey is to first observe the horizontal angle AOB, and then to put the subtense bar up and observe for the distance afterwards. The subtense bar need not be placed exactly on the station—all that is necessary is to measure the distance of the bar from the station.

The advantage of this is that much time is thereby saved.

Very often also it is not practicable to erect the subtense bar exactly over the station, owing to trees or houses or other obstructions.

This is the procedure now laid down in the new Topographical Hand Book, Chapter IV.

It is found that in steep country stations should be close together, so as to localise errors in cutting. In level country, of course, the distance between stations should be as great as possible.

The stations are marked by pegs, and the plane-tablers follow the traversers as soon as possible, so as to prevent the pegs being pulled up and lost.

After the main circuits had been completed, subtraverses were run in all directions along the roads, breaking up the main circuits into small areas for the plane-tabler to work on.

These subtraverses were all closed and adjusted on stations of the main circuits.

Owing to Observatory Hill G. T. H. S. being the only fixed point available for tying the circuits on to, it is possible that the whole survey may be slightly out in azimuth.

This will be checked by triangulating from Observatory Hill H. S. and Birch Hill H. S. to the most N. E. portion of the Lebong circuit. If possible, an intermediate station will be fixed, so as to provide two triangles with a common side. The azimuthal error could also be checked by observing astronomical azimuths, and this will be done in the case of the Takdah survey as there are no G. T. stations convenient for triangulating from. The triangulation method is however quicker when practicable.

As the traversers proceed with their work, they send their field books in to the computers, who compute out the co-ordinates of the stations, and plot them in blue on the field sheets which are then handed over to the surveyors.

The detail is practically all put in by chaining, and the sight rule is only used for cutting in points inaccessible for chaining, inserting nullahs in precipitous ground, and so on. This portion of the work calls for little comment except to mention that each sheet is very rigorously partalled by the Officer in charge of the Survey.

The levelling of these cantonments being a task of some magnitude owing to the difficult nature of the ground, the Superintendent of the Trigonometrical Survey was asked to undertake the work, and he deputed Mr. Syed Zille Hasnain, Extra Assistant Superintendent, to carry out the levelling.

The method adopted was, (apart from the difference in the nature of the ground), precisely the same as that by which the levelling in connection with the recent Delhi Surveys was done. It may be mentioned that Mr. Hasnain was also in charge of this work.

The Lebong levelling started from Observatory Hill G. T. H. S., and by ordinary double levelling for $1\frac{3}{4}$ miles, reached a point within the Lebong Cantonment. From this point a series of circuits and sub-circuits was started. These circuits were so arranged that the heights of the common points were checked by both levellers.

The levelling in the cantonment was only single, but it was run in closed circuits so as to localise any error that there might be; the error allowed along the main lines was 0·02 of a foot per mile.

It was originally intended to pick up as far as possible the traverse stations laid down by the traversers and use these as the level stations. It was found however that these traverse stations were too small, being generally wooden pegs $1\frac{1}{2}$ inches in diameter and 6 inches in length; and it was also a matter of difficulty to find them when buried on one side of the road.

The levellers therefore went on ahead, and did their work independently of the traversers, leaving their stations to be picked up later. They so arranged their circuits that cantonment boundary pillars, parapets of bridges and culverts,

and plinths of important buildings were all picked up and their heights determined.

In addition, specially prepared large wooden pegs 3 inches square in section and 18 inches long were driven into the ground and used as intermediate stations at junctions of roads and other important places.

Roughly speaking, heights have been determined at intervals of about 8 chains all over the cantonment.

Each station is doubly numbered with the number of the section and its own number; thus $\frac{2}{5}$ means the second station in section No. 5; and the position of each is plotted on an existing rough sketch map of the cantonment. Thus, when the traversers follow the levelling, they can easily identify and pick up these points. In addition to the above plot a full description of all the levelled points was prepared and supplied to the traversers.

Lebong was levelled, partly after the traversers had commenced work, and partly before.

In Takdah the whole levelling has been done in advance.

This work originated from a G. T. secondary station Takdah (Deoradanda), H. S., height 6,760 feet, and the same procedure was adopted.

As the contouring had only to be done at a vertical interval of 50 feet, the heights supplied for the surveyors were given to the nearest foot, although they were observed and their computation was carried on to the third place of decimals as usual.

Owing to the steepness of the ground the work progressed slowly. A leveller on an average did $\frac{1}{2}$ a linear mile per day, while in the plains he would have done some 3 miles. It is necessary to mention that this $\frac{1}{2}$ mile would mean a difference in height of some 300 feet and comprise 50 odd stations.

In some cases shots as short as 20 links had to be observed and in consequence special levels had to be selected that would focus at such a short distance.

Ordinary G. T. 10 feet staves were used.

The levelling completed, the surveyors take their P. T. sections and proceed to contour the sheets. In cases where the traversers follow the levelling, the heights are all plotted on the board. Where however the traversers have gone first, the fixed heights are now inserted by chaining on the P. T. sections.

The contouring is done with 2 wooden poles 5 and 15 feet long with plumb bobs on each, and a small horizontal sight piece on the smaller pole. Both poles being plumbed, the long pole is moved about until the top is seen in line with the horizontal piece on the 5 feet pole. This gives a difference in height of 10 feet and this can be either chained to or inserted from detail if there is sufficient available.

From 5 of these differences in heights the 50 feet contour is inserted.

To check the work a few contours will actually be measured along the ground.

The criticism might be made that such an accurate system of levelling is a very expensive method of inserting a 50 feet contour, especially as the 10 feet contours has practically to be first obtained and then only every fifth one used.

It would have been little if any more expense to contour the cantonment at 10 feet intervals than at 50 feet. This was pointed out to the Military authorities, but they decided that all they wanted was the 50 feet interval, and the survey is therefore being contoured at this interval.

F 2

TABLE I.

OUTTURNS OF DETAIL SURVEY.

Scale.	Class of survey.	Circle.	Party.	Locality.	Class of Country.	OUTTURN. Total square miles.	OUTTURN. Average per man per month in square miles.	Average number of fixings per square mile.
¼-inch .	Survey .	E	No. 11	Lower Burma .	Jungle clad hills .	1,628	...	0·5
½-inch .	Survey .	N	No. 1	Siăchen glacier and vicinity, Baltistan.	Hilly . . .	866	...	...
1-inch .	Survey .	N	No. 1	Kashmīr . .	Hilly and mountainous.	4,489	47·7	3·7
		N	No. 2	Punjab .	Open irrigated plains	1,716	38·0(a)	...
		N	No. 4	United Provinces	Flat cultivated plains.	3,699	36·89	18·0(a)
		S	No. 5	Central Provinces and Central India.	Varied, chiefly wooded hills.	2,569	17·2	17
		S	No. 6	Berār and Hyderābād.	Varied, open and broken hills.	1,358(b)	19·2	25
		S	No. 7	Madras and Mysore.	High hills, mostly forest clad.	562	29·3	11
		S	No. 8	Madras . .	Varied, intricate .	1,202	13·4	29
		E	No. 10	Upper Burma .	Densely wooded and mostly hilly.	2,194	30·0	14
		E	No. 11	Karenni and Southern Shan States.	Steep rocky hills, lightly wooded.	1,800	33·3	6
		E	No. 12	Assam . .	Partly open and partly densely wooded.	1,566	20·5	8
1-inch .	Revision Survey.	N	No. 2	Punjab . .	Open irrigated plains	5,589	38·0(a)	...
		N	No. 3	Ganges valley, United Provinces.	Cultivated flat .	6,187	34·9	12·9
		S	No. 5	Central Provinces	Open cultivated plains.	904	75·0	3
		S	No. 7	Madras and Mysore.	High forest clad hills	425	39·4	7
		E	No. 9	Bihār and Orissa	Hilly and wooded .	489	37·7	(c)
		E	No. 10	Upper Burma .	Densely wooded and mostly hilly.	280	45·0	11
		E	No. 11	Southern Shan States.	Steep, rocky hills, lightly wooded.	93	43·2	6
		E	No. 12	Assam . .	Densely wooded hills	178	21·5	4
1-inch .	Re-survey	E	No. 9	Bihār and Orissa	Hilly and wooded .	210	17·2	(c)
1-inch .	Supplementary Survey.	N	No. 4	United Provinces	Flat cultivated plains	2,108	66·34	18(a)
		E	No. 9	Bihār and Orissa	Hilly and wooded .	1,893	21·9	15
		E	No. 12	Assam . .	Plains densely populated with large areas of marsh lands.	1,538	27·5	12
1½-inch .	Survey .	S	No. 7	Madras . .	Low undulating, very intricate.	1,059	13·0	26
		S	No. 8	Madras .	Flat, very intricate .	282	5·0	55
1½-inch .	Revision Survey.	N	No. 2	Punjab, Siwālik hills.	Hilly . . .	64	38·0 (a)	...
		S	No. 7	Madras . .	Low undulating, very intricate.	119	29·8	11
2-inch .	Survey .	S	No. 6	Berār . .	Broken hills, heavily wooded.	408	8·1	58
		S	No. 7	Madras, Mysore and Coorg.	Heavy jungle-clad hills.	182	9·3	47
		S	No. 8	Madras . .	Hilly dense forests .	66	4·4	29
		E	No. 9	Bihār and Orissa	Hilly and wooded .	4	...	...
		E	No. 10	Upper Burma .	Wooded and partly hilly.	215	11·3	57
		E	No. 11	Southern Shan States and Lower Burma.	Low jungle-clad hills	117	11·8	23
		E	No. 12	Assam . .	Densely wooded plains.	77	12·5	26

(a) Worked out from the totals for the whole party and including all descriptions of survey.
(b) Includes 21 square miles also surveyed on the 2-inch scale.
(c) Not recorded separately.
(d) No. 4 Party also carried out approximately 17·5 square miles of 16 inches to 1 mile survey of Quetta Civil Lines and 53 acres of 50 feet to 1 inch survey of Quetta Cantonment. These surveys are not included in this table.
(e) 71 miles of 1-inch trans-frontier sketch survey were also done by No. 10 Party across the Burmese frontier. This is not shown in this table.

TABLE II.

DETAILS OF TRIANGULATION AND TRAVERSING.

Circle.	Party.	Locality.	TRIANGULATION.												TRAVERSING.				
							MINOR.			TERTIARY.			INTERSECTED POINTS.						
			Instrument used; diameter in inches.	Area in square miles.	Square miles to each point fixed.	Square miles to each height.	Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Number of points fixed.	Linear error per mile in feet.	Area in square miles.	Linear miles of chaining.	Number of stations at which theodolite was set up.	Angular error per station in seconds.	Linear error per 1000.
N	No. 1	Kashmir	6	8,421	7·9 (a)	7·9 (a)	39 (a)	10·6 (a)	0·38 (a)	...	...	...	343 (a)	1·32(a)	...	...	...	..	...
N	No 2	Panjab	...	No triangulation or traversing were done this year.															
N	No. 3	United Provinces . .	...	No triangulation or traversing were done this year.															
N	No. 4	United Provinces . .	6	..	...	...	...	...	...	...	...	...	...	...	...	60·3	200	1·8	0·07
N	No. 4	Quetta Cantonment and Civil Lines (50ft.=1 in. & 16 in.=1 m.)	6	17·53	5·8	5·8	15	18·0	0·17	...	...	...	30	0·20	17·53	92·71	463	6·0	0·13
S	No. 5	Central Provinces . .	6	2,493	3·6	3·6	...	...	...	74	11·9	0·2	610	0·6	...	...	...	...	...
S	No. 6	Berār and Hyderābād . .	6	2,800	(b)	(b)	35	9·3	0·2	49	9·2	0·2	(b)	(b)	...	707	5,718	4·4	(b)
S	No. 7	Madras and Mysore . .	6	2,321	6·0	6·9	13	4·8	0·1	11	7·0	0·1	351	0·5	...	...	...	...	...
S	No. 8	Madras	...	...	...	...	...	...	...	...	...	...	...	...	...	182	1,284	6·0	1·7
E	No. 9	Bihār and Orissa . .	6	7,559	7·9 (a)	7·9 (a)	...	...	...	...	19 (a)	0·4 (a)	753 (a)	1·6 (a)	...	164 (c)	1,815	(b)	(b)
E	No. 10	Upper Burma	6	2,336	(b)	(b)	(b)	(b)	(b)	...	...	...	(b)	(b)	500	387	5,253	4·0	0·7
E	No. 11	Karenni, Southern Shan States and Lower Burma.	6	3,950	5·7	5·7	31	11·3	0·1	...	...	...	637	0·4	...	...	...	...	...
E	No. 12	Assam	6	870	5·8	5·8	12	9	0·1	...	...	...	137	0·6	2,386	491	2,196	3·7	1·5

(a) These figures do not apply to the whole area triangulated as the computations were not completed.
(b) Figures not computed in time for insertion.
(c) Forest boundary traversing.

TABLE III.

COST-RATES OF SURVEY.

Circle.	Party.	Locality.	Class of country.	COST-RATES, RUPEES. ¼-inch survey.	½-inch survey.	1-inch survey.	1-inch revision survey.	1-inch resurvey.	1-inch supplementary survey.	1½-inch survey.	1½-inch revision survey.	2-inch survey.	TRIANGULATION, PER SQUARE MILE. Minor and tertiary.	TRAVERSING, PER LINEAR MILE. Topographical.	Forest boundary.	Fair mapping, per square mile.	Total survey outturns on all scales, square miles.	Total cost of party. Rs.	Inclusive cost-rate per square mile.	REMARKS.
N	No. 1	Kashmir and Baltistan, Siāchen glacier.	Hilly and mountainous	...	1·1(a)	16·2	...	...	...	...	...	...	4·3	...	...	7·1	4,489	1,36,287	30·4	(a) Cost-rate derived from share paid by the Survey of India. Mrs. Bullock Workman paid the remainder.
N	No. 2	Punjab	Open irrigated plains	...	...	8·5	...	...	...	...	...	...	...	...	...	8·2	7,369	1,06,116(b)	14·4	(b) Excludes Rs. 4,718 on Delhi Special Survey.
N	No. 3	Ganges valley, United Provinces.	Cultivated flat	...	...	...	9·02	...	...	...	...	...	...	...	...	4·8	6,187	85,063(c)	13·7	(c) Excludes Rs. 4,166 on Delhi Special Survey.
N	No. 4	United Provinces	Flat cultivated plains	...	...	(d) 10·04	...	...	(d) 10·04	...	...	...	...	79·4	...	4·79	5,807	1,01,163(e)	17·4	(d) Combined cost-rate of survey and supplementary survey.
S	No. 5	Central Provinces and Central India.	Varied, revision survey open plains.	...	...	20·1	3·0	...	...	...	...	...	11·4	...	.	8·0	3,478	1,04,806	30·2	(e) Excludes Rs. 20,737 spent on about 17·5 square miles of 16 inches to 1 mile survey of Quetta Civil Lines and also Rs. 2,240 spent on about 53 acres of 50 feet to 1 inch survey of Quetta Cantonment.
S	No. 6	Berār and Hyderābād.	Varied, 2-inch survey intricate forests.	...	...	22·1	...	...	...	...	...	45·5	7·9	...	18·4	10·5	1,745	98,521	56·5	
S	No. 7	Madras, Mysore and Coorg.	Varied, intricate	...	...	12·0	9·8	...	...	25·0	7·7	44·6	2·6	...	...	11·3	2,347	83,359	35·5	(f) Includes revision and supplementary survey. Cost not kept separate.
S	No. 8	Madras	Varied, very intricate and mostly wooded.	...	...	58·5	...	...	...	2·0	...	90·8	...	27·5	...	20·3	1,550	1,22,780	79·2	(g) Excludes Rs. 14,587 for traversing of forest boundary and Rs. 6,818 for Punjab mapping.
E	No. 9	Bihār and Orissa	Hilly and wooded	...	...	...	...	21·3(f)	...	...	...	...	4·6	...	88·9	7·3	2,596	1,01,971(g)	39·2	
E	No. 10	Upper Burma	Wooded and partly hilly.	...	..	24·1	18·1	...	...	...	...	30·2	7·3	67·6	87·8	14·6	2,688	1,36,774(h)	50·9	(h) Excludes Rs. 25,722 for exploration and forest boundary surveys and training of Burma Land Records Officers.
E	No. 11	Southern Shan States, Karenni and Lower Burma.	Steep rocky hills lightly wooded. Low jungle-clad hills.	4·2	...	33·1	7·5	...	...	...	...	47·5	8·3 (i)	...	...	11·8	3,638	1,38,176	37·9	(i) Includes triangulation for ¼-inch survey. (j) Includes traversing.
E	No. 12	Assam	Partly open and flat and partly wooded and hilly.	...	...	25·0	23·7	...	18·5	...	...	40·4	8·8 (j)	(k)	(k)	7·9	3,359	1,30,097(l)	38·7	(k) Cost not recorded separately. (l) Includes cost of forest boundary traversing not recorded separately.

PART II.—GEODETIC SURVEY.

ASTRONOMICAL LATITUDES.

No. 13 PARTY.

(*Vide* Index Map 10.)

BY CAPTAIN H. J. COUCHMAN, R.E.

PERSONNEL.

Imperial Officers.

Major H. L. Crosthwait, R.E., in charge.

Upper Subordinate Service.

Mr. Bidhu Bhushan Shome.

Lower Subordinate Service.

2 computers, etc.

During the season 1911-12 only one officer was available for the two geodetic parties. This necessitated the selection of the same area for both latitude and pendulum operations, and one, moreover, where no long marches were necessary. The plains of Bengal were therefore chosen, and, in view of the large southerly deflection, $+10''\cdot75$ found previously at Hurilaong (near Daltonganj) on the Hurilaong Meridional Series, this series and the Gurwāni Meridional Series were selected together with two stations on the Calcutta Longitudinal Series south of Hurilaong.

In addition to the 10 stations visited on these three series, one secondary station in the Siwālik hills was also occupied. The health of the party remained good throughout the field season.

The new Zenith Telescope by Messrs. T. Cooke and Sons was used for the first time this year, and, it may be here stated, gave satisfactory results. This instrument is larger than the old Zenith Telescope hitherto used, and has to be entirely taken to pieces on completion of work at a station, but, with practice, this does not take long.

The principal dimensions, etc., of the new instrument are as follows:—

Focal length	41 inches.
Diameter of object glass	3 „
Transit axis length	19½ „
„ „ diameter	2¼ „
Total height of instrument (telescope vertical) . . .	4 ft. 8 inches.
Magnifying power of eye-pieces provided	40, 60 and 90.

Of these 60 was always used for latitude work, and 90 for measuring the micrometer wire intervals A. B. and B. C.

The total weight of the instrument is 160 lbs., and with its boxes 260 lbs.

The illumination of the field is effected by an electric glow lamp, placed either in front of the object glass and reflected down the tube, or at the end of the transit axis. The former was generally used as being more satisfactory. An oil lamp is also provided in case the batteries or glow lamp should fail, but the light therefrom is not so good.

There are two Talcott levels, and, in addition to the ordinary rim clamp, a central screw clamp is provided, by tightening which the levels can be rigidly fixed to the telescope.

Determinations of the scale values of the levels were made at the beginning and end of the field season. The mean values used were:—

Level No. 1 value of 1 Division	$0''\cdot858$
Level No. 4 „ „	$0\cdot975$

The length of 1 Division of Level No. 1 is more than twice as great as that of No. 4. The former level is thus the more sensitive of the two.

The individual values on which these means are based are not very satisfactory, more especially those taken at the beginning of the field season. Each level is enclosed in an oblong wooden case, and before placing on the bubble tester, it is necessary to take out the glass level tubes from these cases. The levels are therefore quite unprotected from air currents and changes of temperature during testing, and this probably explains the discordant results. It is however hoped that some device can be invented which will obviate this.

The probable error of the mean value of 1 division cannot however exceed 0″·05, and, as level corrections of over 1″ are very rare and there is no tendency for the corrections to be of one sign, the effect on the final latitude is negligible.

An arrangement is provided in the new instrument for turning the eyepiece through a right angle. This enables the micrometer value to be determined by timing successive transits of a circumpolar star over the movable wire. This method was employed in the field as well as the ordinary one of measuring the difference of declination of two stars of the same aspect. Reference will be made to these results later.

The stations visited and the values of the deflection of the plumb-line obtained are given in the following table :—

TABLE I.

Name of Station.	Longitude.		Height above M. S. L.	Astronomical Latitude.			Seconds of Geodetic Latitude.	Deflection A—G.
	°	′	Feet.	°	′	″	″	″
Bulbul H. S.	84	26	3,352	23	37	53·44	44·63	+ 8·81
Teona H. S.	84	10	740	24	34	49·76	38·94	+10·82
Mednipur T. S.	84	22	335	25	5	22·35	14·02	+ 8·33
Nuaon T. S.	84	14	251	25	34	45·64	37·94	+ 7·40
Jalālpur T. S.	84	23	232	26	3	45·56	39·42	+ 6·14
Mahwāri H. S.	84	54	3,153	23	26	9·28	4·96	+ 4·32
Mahār H. S.	85	10	1,606	24	44	31·12	20·88	+10·24
Bihār H. S.	85	31	391	25	12	39·27	26·05	+13·22
Dubauli T. S.	85	20	189	25	40	22·99	16·23	+ 6·76
Pahlādpur T. S.	85	27	175	26	4	27·24	21·01	+6·23
Khajnaur h. s.	77	53	2,576	30	15	56·70	23·63	—26·93

A+ sign denotes a southerly attraction of the plumb-line.

Bulbul H. S.—Is on the extreme northern edge of the hills which extend for some distance to the south. The ground immediately to the north drops steeply to about 1,000 ft. and there are scattered hills, (on one of which Hurilaong H. S. is situated), running up to 2,000 ft., and under. The distribution of local masses leads one to expect a marked southerly deflection.

Teona H. S.—Is on the top of a small granite hill rising some 250 ft. from the plain. The country generally is flat, the nearest hills being about 12 miles south. Purely local masses would seem to cause a slight northerly attraction.

Mahwāri H. S.—Is on the summit of a hill about 900 ft. above the elevated plateau which extends from the hills on which Bulbul H. S. stands to

some miles east of Ranchi. There are other scattered hills near by but otherwise the country is flat. The mass of the hill itself indicates a slight northerly deflection.

Mahār H. S.—The ridge on which this station stands extends for about 2 miles in the directions N. N. E. and South. The slopes are steep to the east, and to the west a spur runs for about 400 yards and the ground then falls rapidly. The country generally is flat but with scattered hills rather more numerous than at Mahwāri. The distribution of local masses should cause a small northerly attraction, but the hills to the south will more than overcome this.

Bihār H. S.—At this station the largest southerly deflection as yet discovered in India has been found. It stands on a low hill rising 200 ft. from the Gangetic plain which extends to the Himālaya on the north and for vast distances to east and west. The nearest hills to the south are about 12 miles away. The hill itself extends about 600 yards E. N. E. and 900 yards S. W. of the station. The ground falls almost sheer on the north-west face of the hill, the latitude pillar being about 30 ft. from the edge. To the south-east the slope of the hill is about 10°. The closeness of the cliff to the latitude pillar must account for a portion of the southerly deflection and taking the mass of the hill as a whole there is also a preponderance to the south.

The remaining tower stations are all in the Gangetic plain, Pahlādpur, the most northerly, being about 100 miles from the outer Himālaya.

Khajnaur h. s.—Is in the Siwālik hills about 10 miles S. S. W. of Dehra Dūn. It stands on a spur running slightly west of north from the main range. The ground drops steeply to the north and the attraction of purely local masses is probably southerly.

Before discussing the results some further details of the observations are given in Table II below:—

TABLE II.

STATION.	Number of stars.	Number of observations.	P. E.	P. E. of unit weight.	E.W.-W.E.	Apparent error of Micrometer value per revolution.
			″	″	″	″
Bulbul	63	65	±0·065	±0·357	—0·10	+0·0067
Teona	61	69	±0·061	±0·330	+0·06	+0·0035
Mednipur	58	67	±0·061	±0·320	—0·15	+0·0073
Nuaon	60	70	±0·059	±0·314	—0·17	+0·0055
Jalālpur	57	71	±0·043	±0·224	—0·17	+0·0067
Mahwāri	57	59	±0·051	±0·265	—0·06	—0·0022
Mahār	59	54	±0·054	±0·281	—0·01	+0·0031
Bihār	59	60	±0·048	±0·245	+0·26	+0·0060
Dubauli	63	69	±0·052	±0·282	+0·02	+0·0114
Pahlādpur	58	64	±0·047	±0·242	—0·28	+0·0114
Means	60	65	...	±0·286	—0·06	+0·0059
Khajnaur	36	22	±0·087	±0·312	—0·63	+0·0086

The probable errors in column 4 are somewhat higher than have been obtained in previous years with the old Zenith Telescope. This is no doubt due to the mean value of one revolution of the micrometer being in error. The persistence of the positive sign in the apparent error of micrometer value, (last column of the table), shows that the value used was probably too high. As stated above, this value was obtained in two ways:—

(1) By measuring the difference of declination of two stars.

(2) By timing successive transits of a circumpolar star, the eyepiece being turned through a right angle.

The mean values by each method were:—

(1) $50''\cdot011 \pm 0''\cdot0042$

(2) $50''\cdot047 \pm 0''\cdot0037$

and, as the probable errors by both methods were about the same, a simple mean $50''\cdot029$ was used in computing the latitude.

The second method has two disadvantages:—

(*a*) If the eyepiece be not turned through exactly 90°, the micrometer value deduced will always be too great and will equal R cosec γ, where γ is the angle through which the eyepiece is turned and R the true value of one revolution. An error of 1° will increase R by $0''\cdot008$.

(*b*) In moving the eyepiece it may possibly be slightly pulled in or out. This will alter the focus and the micrometer value. Besides these objections it is difficult to obtain satisfactory results by timing the transits by eye and ear. A chronograph is almost essential and this means more weight to carry in the field. It seems better, therefore, to keep to the old method of determining the micrometer value.

The probable errors at Dubauli and Pahlādpur were recomputed using the value $50''\cdot011$. These were found to be 0·033 and 0·035 against 0·052 and 0·047, a considerable increase in accuracy. The effect on the colatitude is negligible, as positive and negative micrometer corrections are made to balance.

The deflection of the plumb-line at Khajnaur is less than those found at the four Siwālik stations observed at the previous year, which ranged from $28''\cdot90$ to $29''\cdot59$. None of these stations, however, were definitely on the northern slope of the range, as Khajnaur is, so that the decrease in northerly deflection was to be expected.

At all the other stations the deflections are southerly and seeing that the most northerly is only 100 miles south of the Himālaya and nearly 150 miles north of the hills round Hazāribagh, these results are at first surprising. Similar results have, however, been found previously, though not perhaps quite so close to the Himālaya.

The pendulums have shown that a trough of low density exists over all this area north of the Ganges and that the depth of the trough increases as the Himālaya are approached. This satisfactorily explains the southerly deflections as the northerly attraction of the Himālaya is minimised. The "hidden chain" to the south also increases the southerly deflections.

The decrease between Teona and Bulbul and between Mahār and Mahwāri indicates that gravity is in excess between these stations and the pendulum results have shown that this is the case.

The position of Bulbul at the extreme north edge of the hill must account for a portion of the southerly deflection and, when local topography has been allowed for, the change between Teona and Bulbul will probably be still greater than at present, showing more clearly the excess of gravity between the two stations. It seems probable that the summit of the chain of high density passes close to Mahwāri and Bulbul and observations south of this line should be of great interest.

The large deflection at Bihār would also seem to point to an excess of gravity between that station and Mahār but, as explained above, it is probable that local masses account for a considerable portion of the deflection.

PENDULUM OPERATIONS.

No. 14 PARTY.

(*Vide* Index Map 10.)

BY CAPTAIN H. J. COUCHMAN, R.E.

PERSONNEL.
Imperial Officer.
Captain H. J. Couchman, R.E., in charge.
Provincial Officer.
Mr. Hanuman Prasād.
Lower Subordinate Service.
4 computers.

The area selected for pendulum observations during the season 1911-12 extends from Ranchi and Daltonganj on the south to Muzaffarpur and Gorakhpur on the north. The large southerly deflection of the plumb-line, (+11″), which had been found at Hurilaong, near Daltonganj, seemed to show that the belt of high density passed close to the south and gravity operations were accordingly undertaken to endeavour to determine more accurately the limits of this belt. The health of the party was good throughout the field season. The stations visited were :—

TABLE I.

Station.	Latitude.			Longitude.		Height above mean sea level.
	°	′	″	°	′	Feet.
1. Japla	24	31	58	84	0	474
2. Daltonganj	24	2	5	84	4	707
3. Ranchi	23	23	5	85	19	2,167
4. Gaya	24	47	42	85	0	361
5. Monghyr	25	22	53	86	28	154
6. Arrah	25	34	10	84	39	188
7. Sasaram	24	57	21	83	59	340
8. Moghalsarai	25	17	3	83	6	257
9. Buxar	25	34	42	83	59	207
10. Muzaffarpur	26	7	5	85	25	179
11. Majhauli Rāj	26	17	46	83	58	219
12. Gorakhpur	26	44	58	83	23	257

Ranchi is near the eastern edge of the high plateau which forms the southern edge of the Ganges valley. Daltonganj is on the banks of the Koel river and is surrounded by detached hills running up to 1,000 or 1,500 feet. Japla is a few miles from the Son river on level ground with hills some 15 miles to the south. Gaya and Sasaram are close to the extreme southern edge of the Gangetic plain. The remaining stations are in this plain, Monghyr, Buxar and Moghalsarai being close to the river. The distance of the most northerly station, Gorakhpur, from the Himālaya is about 60 miles and its position is thus roughly comparable to that of Kaliāna, south of Dehra Dūn.

At all these stations, thanks to the kindness of Civil and Public Works Department Officers, good rooms were placed at my disposal for the observations. Four complete sets of swings were made at each place, except where bad weather necessitated the extension of the observations. The average and hourly changes of temperature are given in the following table :—

TABLE II.

STATION.	NIGHT.		DAY.		MEAN.	
	Average temperature.	Hourly change.	Average temperature.	Hourly change.	Average temperature.	Hourly change.
	° C	° C	° C	° C	° C	° C
Dehra Dūn	21·18	+0·12	20·74	+0·16	20·96	+0·14
Japla	22·03	+0·10	21·52	+0·18	21·78	+0·14
Daltonganj	19·20	+0·11	18·50	+0·20	18·85	+0·16
Ranchi	16·00	+0·09	15·54	+0·06	15·77	+0·08
Gaya	18·35	+0·09	18·02	+0·11	18·19	+0·10
Monghyr	17·57	+0·08	17·62	+0·11	17·59	+0·09
Arrah	19·68	+0·03	19·54	+0·16	19·61	+0·09
Sasaram	20·81	+0·07	20·52	+0·15	20·66	+0·11
Moghalsarai	23·08	+0·06	22·58	+0·12	22·83	+0·09
Buxar	22·47	+0·04	21·54	+0·12	22·01	+0·08
Muzaffarpur	21·78	+0·07	21·25	+0·13	21·52	+0·10
Majhauli Rāj	24·35	+0·05	24·02	+0·12	24·18	+0·08
Gorakhpur	27·03	+0·07	26·52	+0·08	26·77	+0·08
Dehra Dūn	24·08	+0·12	24·00	+0·19	24·04	+0·16

The hourly change is everywhere an increase. It is desirable that the changes at field stations should be similar to that at Dehra Dūn, since gravity results are differential and any error due to lag of temperature will be approximately the same at all stations and will therefore be cancelled. This increase of temperature was, therefore, desired, and is, indeed, more easily arranged than a decrease.

Observations for the flexure of the stand were made at the commencement and close of work at each station, two sets being as a rule taken. The following table shows the mean value before and after work and the mean adopted for each station:—

TABLE III.

Station.	Date.	Observed flexure.	Adopted flexure.
		Sec.	Sec.
Dehra Dūn . .	4th November 1911 . .	$37 \cdot 2 \times 10^{-7}$	
	9th " " . .	38·9	38×10^{-7}
Japla . . .	22nd " " . .	63·2	
	29th " " . .	61·3	62
Daltonganj . .	6th December " . .	43·4	
	11th " " . .	43·4	43
Ranchi . . .	29th " " . .	42·9	
	3rd January 1912 . .	45·3	44
Gaya . . .	10th " " . .	42·6	
	16th " " . .	42·6	43
Monghyr . .	19th " " . .	36·6	
	23rd " " . .	36·0	36
Arrah . .	29th " " . .	53·8	
	3rd February " . .	51·3	53
Sasaram . . .	9th " " . .	47·7	
	13th " " . .	47·6	48
Moghalsarai . .	18th " " . .	41·7	
	22nd " " . .	40·4	41
Buxar . . .	27th " " . .	43·8	
	2nd March " . .	43·6	44
Muzaffarpur . .	7th " " . .	46·5	
	11th " " . .	46·2	46
Majhauli Rāj . .	15th " " . .	40·5	
	19th " " . .	40·6	41
Gorakhpur . .	25th " " . .	41·9	
	29th " " . .	42·5	42
Dehra Dūn . .	8th April " . .	36·6	
	12th " " .	36·0	36

The clock rate was determined by Mr. Hanuman Prasād, using the Bent Transit Instrument by Messrs. Troughton and Simms. The mean p. e. of a clock rate determined from observations on two successive nights was ±0·013 sec. and the mean p. e. of the rate derived from observations to one star on two successive nights was ± 0·056 sec.

Table IV shows the times of vibration of the four pendulums at Dehra Dūn in November 1911 and April 1912. The mean time of vibration, 0·5072516 sec., has been adopted for reducing the season's observations :

TABLE IV.

Date.		137	138	139	140	Mean.
	1911.					
Nov.	4—5	0·5072570	0·5074990	0·5071609	0·5070887	0·5072514
	5—6	2593	4998	1619	0877	2522
	6—7	2564	5001	1620	0882	2517
	7—8	2574	4984	1629	0886	2518
	Mean .	0·5072575	0·5074993	0·5071619	0·5070883	0·5072518
	1912.					
Apl.	8—9	0·5072568	0·5074987	0·5071607	0·5070883	0·5072511
	9—10	2592	4996	1611	0870	2517
	10—11	2585	4982	1615	0865	2512
	11—12	2584	4990	1617	0883	2519
	Mean .	0·5072582	0·5074989	0·5071612	0·5070875	0·5072515
General mean .		0·5072579	0·5074991	0·5071616	0·5070879	0·5072516
Difference, April—Nov.		+7	—4	—7	—8	—3

The increase in the mean time of vibration, which, as mentioned in last year's report has been going on since November 1909, has continued, the mean for the season 1910-11 having been 0·5072504.

During April the pendulums were also swung in the new room at Dehra Dūn which forms a part of the lately built bar alley and seismograph house. This room will be brought into regular use from the commencement of the next field season; the observations made this year show that there is no appreciable difference between the two rooms.

In Table V are shown the times of vibration of the mean pendulum at all stations, together with the values of g deduced therefrom. The value of g at Dehra Dūn is assumed to be 979·063 dynes:

TABLE V.

Station.	Time of Vibration.	Difference from Dehra Dūn.	Observed value of g.
	Sec.	Sec.	Dynes.
Dehra Dūn	0·5072516	...	979·063
Japla	0·5073051	0·0000535	978·856
Daltonganj	0·5073127	0·0000611	978·827
Ranchi	0·5073480	0·0000964	978·691
Gaya	0·5072980	0·0000464	978·884
Monghyr	0·5072916	0·0000400	978·909
Arrah	0·5072893	0·0000377	978·918
Sasaram	0·5072930	0·0000414	978·903
Moghalsarai	0·5072889	0·0000373	978·919
Buxar	0·5072852	0·0000336	978·933
Muzaffarpur	0·5072851	0·0000335	978·934
Majhauli Rāj	0·5072866	0·0000350	978·928
Gorakhpur	0·5072846	0·0000330	978·926

Table VI shows for each station the observed value of g, the corrections for height, mass and terrain and the deduced value of g_o'' at sea level; γ_o is the theoretical value of gravity at sea level, derived from Helmert's 1884 formula. $\gamma_o = 978·00\ (1 + ·005310 \sin^2 \phi)$, where ϕ is the latitude of the station.

TABLE VI.

STATION.	Latitude.	Longitude.	Height above M. S. L.	Observed value of g	Correction for height.	Correction for Mass.	Correction for Terrain.	$g_o = g$ corrected for height.	$g_o'' = g$ corrected for height, Mass and Terrain.	γ_o	$g_o - \gamma_o$	$g_o'' - \gamma_o$
	° ′ ″	° ′	Feet.	Dynes.	Dynes.	Dynes.		Dynes.	Dynes.	Dynes.	Dynes.	Dynes.
Japla	24 31 58	84 0	474	978·856	+0·044	—0·017	0	978·900	978·883	978·895	+0·005	—0·012
Daltonganj	24 2 5	84 4	707	978·827	+0·066	—0·025	0	978·893	978·868	978·861	+0·032	+0·007
Ranchi	23 23 5	85 19	2,167	978·691	+0·202	—0·076	0	978·893	978·817	978·818	+0·075	—0·001
Gaya	24 47 42	85 0	361	978·884	+0·034	—0·013	0	978·918	978·905	978·913	+0·005	—0·008
Monghyr	25 22 53	86 28	154	978·909	+0·014	—0·005	0	978·923	978·918	978·954	—0·031	—0·036
Arrah	25 34 10	84 39	188	978·918	+0·018	—0·007	0	978·936	978·929	978·967	—0·031	—0·038
Sasaram	24 57 21	83 59	340	978·903	+0·032	—0·012	0	978·935	978·923	978·925	+0·010	—0·002
Moghalsarai	25 17 3	83 6	257	978·919	+0·024	—0·009	0	978·943	978·934	978·947	—0·004	—0·013
Buxar	25 34 42	83 59	207	978·933	+0·019	—0·007	0	978·952	978·945	978·968	-0·016	—0·023
Muzaffarpur	26 7 5	85 25	179	978·934	+0·017	—0·006	0	978·951	978·945	979·006	—0·055	—0·061
Majhauli Raj	26 17 46	83 58	219	978·928	+0·020	—0·008	0	978·948	978·940	979·019	—0·071	-0·079
Gorakhpur	26 44 58	83 23	257	978·936	+0·024	—0·009	0	978·960	978·951	979·052	—0·092	—0·101

The last column of the table shows the amount by which gravity is in excess or defect assuming that all surface masses are entirely uncompensated and of density 2·8. The column headed $g_0—\gamma_0$ shows the residuals based on the assumption that surface masses have no effect. These residuals need not be considered, as whatever theory of underground compensation is assumed, it is certain that surface masses must always produce some effect on gravity.

Considering, then, the values of $g''_0—\gamma_0$ it is first to be observed that these are all negative with the sole exception of Daltonganj. This was to be expected for the stations in the Gangetic plain, as these are fairly close to the Himālaya and we find the same decrease in gravity residuals as the hills are approached as was discovered from Kisnapur to Siliguri and Meerut to Dehra Dūn. The *actual* defect here is, however, greater than has been found previously, for at Kaliāna, which is about the same distance from the Himālaya as Gorakhpur, the defect in gravity is ·058 and at Kesarbari, which is slightly nearer, it is ·043.

The whole of this season's area north of the Ganges may, therefore, be considered as a trough of unusually low density and this may help to explain the large southerly deflections which have been found south of the river, at Bihār, Mahār, Teona and Hurilaong, *vide* the Report of No. 13 Party, (Astronomical), page 40. The effect of this trough is to mask the attraction of the Himālaya, as in itself it produces a southerly deflection at stations south of it.

With regard to the location of the hidden chain of high density, it is perhaps unfortunate that no observations were made south of Daltonganj and Ranchi. Practical considerations, however, prevented this; there is no railway and an observatory for the pendulums would have been hard to find. A study of the deflections of the plumb line found this year seems, however, to show that the crest of the "hidden chain" must be somewhere near Ranchi and though gravity is actually shewn to be slightly in defect there, it is less in defect than at stations to the north, Gaya and Arrah. Ranchi, therefore, is probably on the "hidden chain," but until observations are continued southwards it is not possible to define the actual crest.

The greater part of the recess season has been spent in an investigation of the isostatic theory as far as concerns gravity results. The particular theory employed is that of Mr. Hayford, which, stated shortly, is that compensation is complete at a depth of 70 miles. Above that depth, therefore, the amount of matter in a cylinder standing on a base of unit area and extending from 70 miles below sea-level to the earth's surface is always the same whatever the height of the cylinder.

In Volume I of the Records of the Survey of India, 1909-10, mention was made of this investigation but as at that time it had only been carried to a distance of 100 miles from each station, no figures were given. Outside this radius the zones and compartments into which the surface of the earth is divided are those used by Mr. Hayford, who has so designed them that a mean height of 100 feet in each compartment produces a correction of 1×10^{-p} dynes, p being an integer increasing from 4 to 6. No check has been applied to his calculation of the radii of zones.

Inside the 100 miles radius, zones differing from those of Mr. Hayford have been used and the necessary reduction tables for them were computed

by Captain H. M. Cowie, R.E., and recomputed by me. The radii of these zones are :—

Zone No.	Outer Radius.	Zone No.	Outer Radius.
1	10 feet	9	3 miles.
2	200 „	10	5 „
3	600 „	11	8 „
4	1,400 „	12	12 „
5	2,640 „	13	20 „
6	1 mile	14	32 „
7	1½ miles	15	60 „
8	2 „	16	103·6 „

The outer radius of zone 16 is the same as the inner radius of Mr. Hayford's zone 18 which, expressed as the angle subtended at the earth's centre, is 1° 29′ 58″, and as his zones extend to the antipodes the whole surface of the earth is dealt with.

Dealing first with the stations visited this year, the following are the residuals after applying "Hayford" corrections for topography and compensation. For the sake of comparison the Bouguer residuals are also shown, and have been recomputed using the same surface density of the earth (2·67) as that assumed by Mr. Hayford. The mean surface density used in our gravity work is 2·8 :—

STATION.	g—γ		Difference H—B dynes.
	Hayford (H) dynes.	Bouguer (B) dynes.	
Ranchi	+·054	+·003	+·051
Daltonganj	+·050	+·008	+·042
Japla	+·027	—·011	+·038
Gaya	+·028	—·007	+·035
Sasaram	+·033	—·001	+·034
Moghalsarai	+·020	—·013	+·033
Monghyr	±·000	—·036	+·036
Arrah	—·003	—·038	+·035
Buxar	+·010	—·023	+·033
Muzaffarpur	—·016	—·061	+·045
Majbauli Rāj	—·034	—·079	+·045
Gorakhpur	—·046	—·101	+·055

It is first to be observed that the difference H— B is positive in every case. If, however, we use Helmert's 1901 formula for the normal value of gravity at sea-level, we reduce these positive values. This formula referred to the Potsdam system (as our base value at Dehra Dūn is) is $978{\cdot}030\ (1+0{\cdot}005302 \sin^2 \phi - 0{\cdot}000007 \sin^2 2\phi)$ where ϕ is the latitude of the station.

The values of γ computed by this formula are greater than the old values by ·025 for the first 6 stations of the table, Ranchi to Moghalsarai, and by ·024 for the remainder. The values of $g-\gamma$, (Hayford), should therefore be decreased by this amount and we have the following residuals :—

STATION.	$g-\gamma$	STATION.	$g-\gamma$
Ranchi	+·029	Monghyr	—·024
Daltonganj	+·025	Arrah	—·027
Japla	+·002	Buxar	—·014
Gaya	+·003	Muzaffarpur . . .	—·040
Sasaram	+·008	Majhauli Rāj . . .	—·058
Moghalsarai	—·005	Gorakhpur . . .	—·070

The differences H—B will also of course be decreased by the same amounts and will vary from +·031 at Gorakhpur and + ·026 at Ranchi to +·008 at Moghalsarai.*

As might have been expected from a consideration of the problem, the differential residual between two stations in the plains has hardly been changed. It is at stations on and near high ground where differences are to be expected. Thus we find that the excess of gravity at Ranchi is greater than the excess at Gaya by ·026, using Hayford's theory, whereas, by Bouguer's method, the increase is only ·010. Similarly the difference between the residuals at Daltonganj and Sasaram is increased from ·009 to ·017. As we approach the Himālaya the differences between the residuals are decreased by the new method, *cf.* Buxar and Gorakhpur, but the effect of the high ground is the same, as g is increased by a greater amount the nearer the hills are to the station, and as will be seen later the large negative residuals found at the foot of the Himālaya are in some cases converted into positive ones and in all are very greatly reduced.

The new residuals at stations south of the Ganges valley, the first five of the table, seem to be more in agreement with the observed deflections than were the Bouguer residuals. The large excess of gravity at Daltonganj combined with the nearly normal value at Japla helps to explain the big southerly deflection at Hurilaong, (near Daltonganj), and Teona, (near Japla). Similarly

* All Bouguer residuals are computed using Helmert's 1884 formula for γ_0. The 1901 formula has only been employed for the Hayford residuals.

the excess at Ranchi combined with the defect at Arrah accounts for the southerly deflection at Bihār, (40 miles south-east of Arrah), and Mahār, (close to Gaya). The hidden chain is also well shown, but as mentioned above we cannot yet be certain of the actual crest.

Several stations on the line Calcutta to Darjeeling were next examined and the Hayford residuals found are shewn below. γ has been computed by Helmert's 1901 formula :—

STATION.	Latitude.	g—γ.		H—B.
		H	B*	
	° ′			
Chatra	24 12	+·005	+·009	—·004
Kisnapur . . .	25 2	+·039	+·033	+·006
Jalpaiguri . . .	26 31	—·019	—·096	+·077
Siliguri	26 42	—·039	—·136	+·097

* Bouguer corrections computed with density 2·67.

The residuals at the stations in the plains are not much altered, but close to the Himālaya, as at Jalpaiguri and Siliguri, the change is very great. It is probable, arguing by analogy from Mussoorie, that at Darjeeling the residual will be positive.

On the line of stations from Meerut to Mussoorie on the meridian 78° we have the following :—

STATION.	Lat.	g—γ.		H—B.
		H	B†	
	° ′			
Gesupur	28 33	+·005	—·019	+·024
Meerut	29 0	+·005‡	—·026	+·031
Kaliāna	29 31	—·006	—·057	+·051
Roorkee	29 52	—·043‡	—·106	+·063
Dehra Dūn	30 19	+·003	—·123	+·126
Rājpore	30 24	+·022	—·119	+·141
Mussoorie, (Camels Back) . . .	30 28	+·049	—·100	+·149

† Bouguer corrections computed with density 2·67.
‡ These values are approximate only as the computation of the Hayford correction has not been completed in detail. The first is probably correct within ·002 and the second within ·005.

In Professional Paper No. 12 "On the Origin of the Himālaya Mountains" Colonel Burrard has shown that the rapid change of deflection found all along the foot of the Himālaya can be explained by assuming the existence of a rift in the earth's crust or sub-crust. The residuals given above seem to bear out this theory very well. The deepest part of the rift would seem to be near Roorkee and the slope on the northern side is apparently steeper than on the southern, *vide* Professional Paper No. 12, page 7, line 31. On the Calcutta-Darjeeling series the deepest part of the rift seems to be near Siliguri as Kurseong and Darjeeling will probably give positive residuals.

The increasing positive residuals from Dehra Dūn to Mussoorie seem to show that the Himālaya are not completely compensated. This does not necessarily mean that they are uncompensated but merely that the assumption of *complete* compensation does not entirely explain the observed phenomena. If we make some assumption of partial compensation we shall alter the Hayford correction at every station, but the change will be small except near the Himālaya. A rough computation, made on the assumption that the Himālaya are three-fourths compensated, reduces the residual at Mussoorie by ·036, at Kaliāna by ·010 and at Gesupur by ·005.

It is, however, claimed that the assumption of complete compensation has materially improved the residuals. It has to a great extent got rid of the large negative residuals at the foot of the Himālaya, and has shown more clearly the "rift" at Roorkee and Siliguri and the "hidden chain" at Ranchi, Kisnapur and south of Gesupur.

Hayford residuals have been computed at four stations in Central India. These are here shown :—

STATION.	Height. Ft.	$g-\gamma$.		H—B.
		H	B*	
Seoni	2,032	+·036	+·012	+·024
Saugor	1,757	+·010	—·013	+·023
Khandwa	1,014	+·050	+·040	+·010
Bilaspur	898	+·013	+·001	+·012

* Bouguer corrections computed with density 2·67.

At all these stations gravity is now found to be in excess, but the point to be noted here is that the persistence of negative Bouguer residuals at elevated stations has been explained by the new method. These negative residuals point to the probability of compensation, and we now see that, by assuming compensation, the change in residual between an elevated and a low lying station is reduced. This is also borne out in the case of Ootacamund where the Hayford residual is +·017 compared with a Bouguer residual of – ·020.

At all the stations given above, with the exception of Chatra the Hayford hypothesis has increased the residuals. This is of course due to the decrease of γ caused by the deficiencies of density assumed to lie under elevated

ground. When, however, we approach the coast we expect to find the residuals decreased, as here the assumed excess of density under the sea will increase γ. Chatra is about 170 miles from the Bay of Bengal and there the positive effect of the ocean compensation has just cancelled the negative effect of that of the land. At Cuttack, 50 miles from, and Madras on, the coast the positive effects are more marked. The new residuals are +·006 at Cuttack and −·053 at Madras as against Bouguer residuals of +·029 and +·014. The big negative residual at Madras is somewhat against the isostatic theory, but we cannot assume anything about ocean compensation until other coast stations have been examined. The Bouguer residual at Bombay is +·088 and the new residual will almost certainly be positive but small.

Two other stations, only, have so far been dealt with. These are Pathānkot and Mian Mīr. At the former we have the largest Bouguer residual that has so far been found, −·177 and at the latter there was an apparent small excess +·005. The Hayford hypothesis has accounted for one-third of this difference of residuals, the new figures being −·077 and +·040.

The defect at Pathānkot by the new method is now seen to be little more than at Gorakhpur and seeing that the latter is much farther from the Himālaya, we may reasonably expect to find still greater deficiencies at stations north of it.

The results of applying the new method may be briefly stated thus:—

(1) At all stations within 200 miles of the coast and below about 1,000 feet in height, the new residuals will be less positive than the Bouguer ones.

(2) At all other stations the new residuals will be more positive or less negative than Bouguer. The increase will roughly vary with the height of the station and will become rapidly greater as the Himālaya or other hills are approached.

It must be remembered that our knowledge of the heights in Southern Asia and Tibet is still somewhat vague. In this investigation the height of the Tibetan plateau has been assumed to be 15,000 feet. If we reduce all our estimates of Himālayan and Tibetan heights by 1,000 feet we shall reduce the residual at Dehra Dūn by about ·008.

The effect of all zones outside a radius of about 400 miles (Hayford zone No. 12) has been interpolated from the three charts constructed last year by Major E. A. Tandy, R.E. These charts show the effects of topography and compensation combined of the actual surface of the earth in:—

Chart (1) Zones 11 and 10, 400 to 750 miles.
 ,, (2) Zones 9, 8 and 7, 750 to 1,850 miles.
 ,, (3) Zones 6 to 1, 1,850 miles to antipodes.

For the first chart the effects at 31 stations were computed, for the second, 17, and for the third, 4. Lines of equal effect were then drawn and the effect at any station can thus be read off the chart. This has saved an immense amount of labour.

It is only necessary to add that the Hayford zones 18 to 14 were divided into 10 equal parts and the height in each compartment estimated and entered separately, the mean being then taken.

The table below shows the computation of the total effect at three selected stations. The unit is 0·00001 dyne.

Zone.			Correction at		
Serial No.	Actual No.	Outer radius.	Dehra Dūn.	Arrah.	Madras.
1	1 (Cowie)	10 ft.	+ 34	+ 33	+ 33
2	2 „	200 „	+ 608	+ 348	+ 38
3	3 „	600 „	+ 1,106	+ 152	+ 2
4	4 „	1,400 „	+ 1,598	+ 54	+ 1
5	5 „	½ mile	+ 1,391	+ 18	0
6	6 „	1 „	+ 1,187	+ 8	0
7	7 „	1½ miles	+ 433	0	0
8	8 „	2 „	+ 202	— 1	0
9	9 „	3 „	+ 161	— 6	0
10	10 „	5 „	— 7	— 16	0
11	11 „	8 „	— 263	— 25	0
12	12 „	12 „	— 585	— 30	+ 7
13	13 „	20 „	— 992	— 60	+ 49
14	14 „	32 „	— 1,291	— 84	+ 138
15	15 „	60 „	— 2,562	— 144	+ 652
16	16 „	103·6 „	— 2,990	— 266	+ 932
		° ′ ″			
17	18 (Hayford)	1 41 13	— 582	— 75	+ 200
18	17 „	1 54 52	— 620	— 91	+ 191
19	16 „	2 11 53	— 599	— 101	+ 182
20	15 „	2 33 46	— 620	— 173	+ 166
21	14 „	3 3 5	— 617	— 338	+ 167
22	13 „	4 19 13	— 1,067	— 762	+ 209
23	12 „	5 46 34	— 683	— 513	+ 150
24	11 „	7 51 30	— *910*	— *720*	+ *450*
25	10 „	10 44 0			
26	9 „	14 9 0			
27	8 „	20 41 0	— *200*	— *200*	+ *240*
28	7 „	26 41 0			
29	6 „	35 58 0			
30	5 „	51 4 0			
31	4 „	72 13 0	+ *170*	+ *180*	+ *170*
32	3 „	105 48 0			
33	2 „	150 56 0			
34	1 „	180 0 0			
		TOTAL ...	— 7,698	— 2,812	+ 3,977
		DYNES ...	— ·077	— ·028	+ ·040

Note.— Figures in italics are interpolated from charts.

The first 16 zones are those of Captain Cowie, the remainder from 18 to 1 are Mr. Hayford's. The radii of these latter zones are expressed for convenience

as arcs of a great circle. The inner radius of zone 18 (Hayford), *viz.*, 103·6 miles, is equivalent to an arc of 1° 29′ 58″.

Dehra Dūn is a submontane station about 7 miles from the foot of the Himālaya and its height is 2,240 feet. Arrah is close to the Ganges river in the centre of the Gangetic plain. Madras is on the coast. The signs of the corrections are applicable to γ and not g. Topography produces a positive correction, its compensation a minus, and *vice versâ* for oceans.

At Dehra Dūn we see that the effect of the topography is greater than that of the compensation for the first 9 zones, *i.e.*, up to a distance of 3 miles from the station. Beyond this point, until the extreme zones 6 to 1 are met with, the corrections are all negative showing that land areas predominate. The Himālayas first begin to make themselves felt in zone 11 (Cowie). At Arrah owing to its lesser height the effect of the topography is overcome at a distance of just over one mile. The corrections up to zone 14 (Hayford), are all small, but at this point the Himālayas are met with. At Madras the local effects are small, since the height is only 20 feet. The positive signs beyond zone 11 (Cowie), show that ocean areas predominate.

In the season 1909-10 observations were made at Sultānpur, Latitude 26° 16′ 6″, Longitude 82° 5′, height 314 feet, but the results were not included in the report as the height was not then known. The value of $g_0'' - \gamma_0$, (Bouguer), is —·040 and, as the station is somewhat further from the Himālaya than Muzaffarpur and the Bouguer residual somewhat less, it seems that the trough of low density, of which mention has been made above, extends as far as Sultānpur.

It is proposed to swing the pendulums at Kaliānpur, (the station of origin of the Survey), and stations round during the ensuing field season. The results to be obtained should throw light on the assumed southerly deflection at Kaliānpur.

HENRY GORDON BELL,

LIEUTENANT,

ROYAL ENGINEERS,

Died at Lup Gaz in the Pamirs, July 26th, 1912, aged 27.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1913.

PART III.—TRIANGULATION.

No. 15 PARTY.

(*Vide* Index Maps 9 and 10.)

BY CAPTAIN H. M. COWIE, R.E.

During the year 1911-12, the party provided seven detachments, all of which, however, were not at work contemporaneously. One detachment under Mr. Tresham, Extra Assistant Superintendent, was employed, during the cold weather months, on principal triangulation, making a commencement on the Sambalpur Meridional Series. During the same period, there were at work three secondary detachments on the Ranchi, Bhīr, and Villupuram Series. Both the Ranchi and Villupuram Series were of short length and, being completed before the end of the field season, their personnel was redistributed between two new detachments which started work on the Madura Series and the Bombay network. Still later, at the conclusion of the cold weather season, on the disbanding of the detachments employed in India, a detachment was formed to carry on the work in Kashmīr, for which preparations had been made the previous year. This last detachment closed its field season in October 1912. The work of the Kashmīr Detachment during the summer of 1911 has been recounted in last year's report. This year's report continues the narrative up to the end of the 1912 season. At all times during the year there has thus been some detachment of No. 15 Party at work in the field.

PERSONNEL.

Imperial Officers.

Major H. H. Turner, R.E., in charge.
Lieutenant E. B. Cardew, R.E., up to 30th September 1911.
Lieutenant F. J. M. King, R.E., up to 3rd May 1911.
Lieutenant H. G. Bell, R.E.

Provincial Officers.

Mr. C. H. Tresham.
Mr. Abdul Hai.
Mr. V. D. B. Collins.
Mr. F. W. Smith.
Mr. G. A. Norman.
Mr. B. T. Wyatt.
Mr. Abdul Karīm.
Mr. K. S. Gopalachari.
Mr. V. P. Wainright.
Mr. C. S. McInnes.

Upper Subordinate Service.

Mr. Jugal Bihāri Lal.

Wherever detachments of the party have been engaged, Orissa, Bombay, the districts of South Arcot and Tanjore in Madras, the Hyderābād State and the Gilgit Agency, they have met with willing and effective assistance from local officials. When difficulties arose, these were, in every case, promptly dealt with by the Civil executive and the work of the party was thereby much facilitated.

The health of the personnel varied a good deal between detachment and detachment. In the Sambalpur, Ranchi, and Bhīr detachments the number of cases of sickness was not abnormal, though in the Bhīr detachment a slight outbreak of cholera occurred. Thanks, however, to prompt repressive measures, the disease was stamped out. In the Villupuram and Madura establishments there was a good deal of fever owing, in part, to the locality, in part, to the lateness in the season of the closing of work on the latter series.

The news received in July, from Hunza, of the death of Lieutenant H. G. Bell, R.E., came as a great shock. His letters had given no indication of his

being other than ordinarily well and fit and except for slight temporary indisposition while at Gilgit, he does not appear to have been in ill-health. Only a few days before his death, he paid a visit to the Russian Survey Camp, near Kizil Rabāt, and seems to have been well in spirits as in body. Of his actual illness, it has been impossible to obtain more than the most meagre account. What was found afterwards by post-mortem examination to have been appendicitis began on 19th July when he was encamped practically alone at an observing station near the Mintaka Pass. Getting no relief, he was carried down to his main camp at Lup Gaz, some 8 miles from the Pass. Here, one of his assistant officers arrived on 25th, in response to a message despatched that morning, and found Lieutenant Bell extremely reduced and weak. But until quite near the end, neither he nor Lieutenant Bell had any idea of the extreme gravity of the case. His vitality failing rapidly late that night, Lieutenant Bell died about midnight.

It was proposed at first to bring the body to Gilgit for burial there, but the state of the Kanjut river made this impossible. So interment took place at the Mintaka Pass.

It was due in very great measure to Lieutenant Bell's energy that the operations progressed so far during a short and unfavourable season. Starting rather late in the year, and continually hampered by bad weather, he succeeded nevertheless in having the whole course of the triangulation from Gilgit to Beyik reconnoitred in detail, and, excepting over a distance of some 30 miles, the stations selected and built. At a few of the stations, at both the northern and southern ends of the triangulation, observations also have been completed. When we consider the great altitude at which operations had to be conducted, the difficulties put in the way of rapid work and simple organisation by the unpropitious nature, both of country and climate, the solitude and the physical hardships which had to be faced at all times, we must realise that this Indo-Russian triangulation, the ultimate success of which will undoubtedly be due to Lieutenant Bell's energy and devotion, is fit to rank with the memorable achievements of the Survey of India.

The following accounts deal in greater or less detail with the operations of each detachment:

DETAILS OF PRINCIPAL TRIANGULATION.

Sambalpur Series.—The desirability of a series of principal triangulation on the meridian of 84°, between the parallels of 18° and 24°, has long been recognised; and on additional urgency being given to the matter by the necessity in this region for well fixed points on which to base secondary triangulation for topographical purposes, it was decided to run a principal meridional series emanating from the Calcutta Longitudinal to close on the East Coast Series in about Lat. 19°.

The scheme of operations drawn up tentatively, before the detachment under Mr. Tresham left for the field, contemplated the springing of the new triangulation from the side Birpokar (XLV)-Turer (XLI) of the Calcutta Longitudinal Series. On his arrival on the ground, Mr. Tresham found, however, that the country to the south of the proposed base was most unsuitable for principal triangulation. Plateau lay beyond plateau, each thickly wooded, on which the location at suitable distances apart of mutually visible

stations was extremely difficult. Well-proportioned figures without grazing or obstructed rays could be laid out only by introducing tower stations. The topographical conditions place this region among the most difficult, from the triangulator's point of view, that India has to offer.

This base was accordingly abandoned and reconnaissances were made to the east to locate a suitable site from which the new series might spring. Breaking off from the side Turer-Gobra would have entailed the introduction into the first figure of a side only 7 miles in length and the succeeding figure promised to be still worse proportioned. The side Birpokar-Bagru was also found to be unsuitable. Eventually a feasible scheme of triangulation was evolved, based on the side Bhursu (XLIX)-Harihārpur (L). This consisted of a quadrilateral, as first figure, followed by a pentagon with a central station and a quadrilateral carrying the series from 85°, the mean longitude of the base, in a south-westerly direction till it lay astride the meridian of 84°, whence it trended due south. This scheme involved a deflection by 1° of the series from its ruling meridian of 84°, but this was held to be less objectionable than the adoption of an expensive programme involving the building of tower stations.

Observations were commenced by Mr. Tresham on 13th December and continued by him till 10th January when he handed over charge of the operations temporarily to Lieutenant H. G. Bell, R.E., while he underwent an operation for appendicitis. On recovering from this, he again assumed charge on 28th February and continued work till April 15th when field operations were suspended for the season. The series had by that time been carried south to latitude 22°, and consisted of four quadrilaterals and one pentagon with a central station, the two southernmost figures lying along the meridian of 84°.

An astronomical azimuth was observed by Mr. Tresham, at Bhursu H. S. of the Calcutta Longitudinal Series, latitude 23° 16′, longitude 84° 44′, the difference, (Astronomical-Geodetic), in the value of the Azimuth of Bagru was found to be —6″·07.

Particulars of the work are given below:—

Number of stations observed at	15
„ „ newly fixed	13
„ „ built	17
Length of triangulation completed in miles	112
„ „ still remaining to be done	180
Area of triangulation in sq. miles	2,570
Theodolite used	T. and S. 12-inch micrometer No. V.
Number of triangles observed	21
Maximum triangular error	1″·526
Average „ „	0″·473

DETAILS OF SECONDARY TRIANGULATION.

Kashmīr Secondary Operations.—In 1909, the International Geodetic Conference passed a resolution embodying the desirability of effecting a junction between the Indian triangulation and Russian work in the Pamirs. Accordingly, during the summer months of 1911, after the completion of observations which carried the Kashmīr Principal Series to points not far south of Gilgit, reconnaissances were undertaken of the country intervening

between that series and the Pamīrs, with a view to discovering a practicable route to be followed by the Indo-Russian connection. Three schemes were suggested to the officers entrusted with the reconnaissances.

The first was to extend the Kashmīr Principal Series as far as the Sakiz Jarab range, on which stations would be established to the east of the Darkot pass. From these points it was hoped that observations might be made to Concord and Salisbury Peaks on the Afghan-Russian border, which peaks would be included by the Russian observers in their triangulation on the Pamīrs. The investigation of the practicability of this scheme was undertaken by the late Lieutenant H. G. Bell, R.E. He reported that the main chain of peaks of the Sakiz Jarab range was inaccessible and that the hills immediately to the south, only a little less difficult to negotiate, though they offered a satisfactory view to the north, were hidden from the south by high inaccessible peaks, effectually obstructing triangulation carried from the terminal points of the Kashmīr Principal Series.

A second scheme involved the carrying of secondary triangulation from the Principal Series, up the Yasin and Karambar valleys to the neighbourhood of the Gazan and Bhort passes, from which the Concord and Salisbury peaks might be visible. After finding that the carrying of triangulation to the Darkot pass was not feasible, Lieutenant Bell turned his attention to the Karambar valley. He found that secondary triangulation could probably be taken as far as Harmot or Imit but that beyond this place the valley narrows considerably between precipitous hills and further progress was impossible.

The third alternative scheme was examined by Mr. Wainright. This was for secondary triangulation to break off from the Principal Series just south of Gilgit and to follow the Hunza and Kanjut valleys as far as the Kilik and Mintaka passes and from thence to extend over the Taghdumbash Pamīr to a junction with the Russian points. This scheme was found to be practicable. The valley as far as Hunza is comparatively open and the hills, though difficult, not inaccessible. Beyond Hunza, though the valley narrows in somewhat, fairly well conditioned figures can still be laid out as far as Misgar. Here, in order to obtain triangles of sufficient length of side, the series has to run westward, out of the valley, and bending again in a general northerly direction, approach the Kilik pass from the south-west. From this pass the triangulation can be easily carried across the Taghdumbash Pamīr to the Russian points near the Beyik pass.

As, by the time the reconnaissances had been carried out, the season was getting late and unfavourable weather was setting in, nothing further could be done that year. The Party returned, in the autumn of 1911, to India and a programme of work for 1912 was elaborated. With its final scheme worked up as far as possible, the detachment left India in May 1912 to commence the actual observations. Recruited under Lieutenant H. G. Bell, R.E., during the latter half of April at Rāwalpindi, after completing its equipment, it marched to Gilgit. Bandipur was reached on the 8th May, some little delay having been caused by deep snow encountered in the Tragbal and Burzil passes. By May 31st all the detachment had been assembled at Gilgit and there the plan of operations was given final shape. Reconnaissances of the previous year had shown that the Hunza and Kanjut valleys were probably practicable for triangulation, which, following this course, might be carried up to the Taghdumbash Pamīr to effect a junction with the Russian triangu-

lation, the terminal points of which were situated in the neighbourhood of the Beyik and Sarikoram passes. It was proposed to base the triangulation on a side of the Kashmīr Principal Series in latitude 35° 55′ and longitude 74° 20′; to carry it thence northwards to about latitude 36° 12′, where, following the valley, it would trend eastwards to longitude 74° 20′ and at this point, near Atābād, it would again extend north to the Kilik pass in latitude 37° 07′.

From this pass, the Russian points lie to the north-east on the far side of the Taghdumbash Pamīr in about latitude 37° 20′, longitude 75° 10′.

Between Gilgit and Hunza, the valley of the Kanjut river is comparatively open, the hills on either side are more accessible than is the case higher up the valley and as far as Hunza a graded road runs along the right bank of the stream. In the neighbourhood of Baltit lofty snow masses rise above the valley on both banks. On the left bank, Rakiposhi peak attains a height of 25,550 ft., while towering over the nearer masses on the right are the Hunza peak (25,050 ft.) and a group of summits all over 24,000 ft. in height.

Beyond Baltit the hills close in to the stream, the slopes become barren and rugged and progress correspondingly more difficult. In many places the pathway is carried along the face of precipitous scarps supported, gallerywise, on iron or timber struts; in others the pathway climbs the hill side till it is possible to skirt the top of precipices too formidable to be dealt with by any such type of bridging. These steep ascents and subsequent descents to the villages lying close to the river, make marching in the summer months most trying; the heat in the narrow rocky valley is intense and travelling is, whenever possible, done before sunrise. After the flood water in streams has subsided, about November, the hillside path over the difficult stretches is generally forsaken for the river bed. Four marches above Baltit, the lower end of the much serrated and crevassed Batur glacier is encountered. About 1 mile in width at this point, this glacier, striking the Kanjut valley at right angles, forces its way across the river bed, butting up against the hills on the left bank. Seven marches from Baltit the junction of the streams from the Mintaka and Kilik passes is reached at Murkushi. Here there is a small grassy level thickly covered with willows, the last timber seen on the march to the Pamīrs. From Murkushi two routes lead to the Taghdumbash Pamīr, one *viá* the Kilik, the other over the Mintaka pass.

The scheme decided upon by Lieutenant Bell was that he and Mr. McInnes should march at once to the Russian points on the Beyik pass and, commencing building and observing there, work gradually over the Kilik and Mintaka passes and down the Kanjut valley to effect a junction with the triangulation which Mr. Collins and Mr. Abdul Karīm were to carry from its lower end as far up the Hunza valley as they could. In the meantime Mr. Abdul Hai was to effect a junction between the Kashmīr Principal Series and the figures laid out by Mr. Collins in the Hunza valley.

The various sections left Gilgit for their respective localities during the first week of June, but owing to unfavourable weather, very little reconnaissance and no observing was possible until 23rd. It was during this spell of bad weather that Mr. Abdul Hai's Camp on Yasho Chish Peak was struck by lightning. His servant was killed; his recorder was severely burnt, while he himself received a shock necessitating his return to Gilgit and eventually to head-quarters in India.

Yasho Chish is one of the stations of the Kashmīr Principal Series and was the first point visited by Mr. Abdul Hai in his attempt to effect a connection between this Series and Mr. Collins' Hunza valley work. On the recall of Mr. Abdul Hai, the responsibility of this connection fell to Mr. Collins who had, in the meantime, carried the reconnaissance and building of stations up the right bank of the river as far as Hunza. Leaving Mr. Abdul Karīm to continue from there the building up both sides of the valley, he returned to Gilgit and took up the observations, commencing at the base stations on the Kashmīr Series. By July 28th he had completed work at four stations when he received news of Lieutenant Bell's death and returned again to Gilgit to assume charge of the detachment.

Lieutenant Bell and Mr. McInnes, on leaving Gilgit early in June, marched through the Kanjut valley and over the Mintaka pass to the Russian stations on the Beyik, which they reached on June 20th. Lieutenant Bell then took up the work of observing while Mr. McInnes proceeded southwards towards the Kilik pass, reconnoitring and selecting stations. While on the Beyik, Lieutenant Bell spent one day with the Officers of the Russian Survey Party encamped near Kizil Rabāt. Compliments were exchanged and experiences related. In one of his letters Lieutenant Bell alludes briefly to this meeting; "dressed in long boots of the country and a *choga*, escorted by three local headmen and by Hunza interpreters, I crossed the Beyik pass into the Russian territory to meet the Russian Survey Officers. I was met by a cavalcade consisting of the Colonel, a Captain, a Lieutenant and their escort of cossacks and cavalry."

Lieutenant Bell had completed observations at three stations and had moved camp to his fourth station near the Mintaka pass when he was seized, on 19th July, by an attack of appendicitis. Obtaining no relief and suffering much, he moved down to Lup Gaz, some 8 miles north of the Mintaka pass, and on 25th morning sent to Mr. McInnes, then in the neighbourhood of the Kilik pass, asking for assistance. Mr. McInnes arrived at Lup Gaz on the afternoon of the 25th to find Lieutenant Bell very weak. During the previous five days there had been no sign of any definite improvement in his condition and after Mr. McInnes' arrival at Lup Gaz, the malady seemed to become gradually more acute. Late in the evening Lieutenant Bell began to sink rapidly and about midnight he died. His body was interred temporarily near the Mintaka pass to be brought down later, when the state of the Kanjut river permitted, to Gilgit for burial in the cemetery there.

The detachment was now reduced to three observers. The lateness in the season, the remoteness of the locale of operations and the impossibility, in any case, of completing the triangulation this year, were against the sending of another officer to take Lieutenant Bell's place.

The charge of the detachment now devolved on Mr. Collins, who continued observations on the section between Atābād and Gilgit, directing Mr. McInnes to take up the selecting and building of stations in the difficult country between the former place and Misgar, while Mr. Abdul Karīm undertook the laying out of triangles southwards from the Kilik pass, where Mr. McInnes had stopped, to Misgar. Mr. McInnes laid out six stations, forming sufficiently good figures, carrying the series to Misgar where he connected with Mr. Abdul Karīm's section. This last portion of the triangulation between the Kilik pass and Misgar, however, was very poor. The course selected for the series was badly chosen and the figures laid out were unsatisfactory. Before, however, a better disposition of stations could be arrived at, the weather

Photo. Engraved & printed at the Offices of the Survey of India, Calcutta 1913.

Beyik, July 9th, 1912. Colonel Tchkeine and the Russian Survey Party.

got rapidly worse, and winter began to set in; new snow had fallen down to a level of about 11,000 feet, and the work of observing became daily more difficult. Field operations were accordingly closed on 18th September, the detachment recalled to India and disbanded on October 25th at Dehra Dūn.

Ranchi Series.—A detachment under Mr. Wainright was employed in carrying a series of secondary triangles along the parallel of 23° between the South Parasnath Series and the new Sambalpur Series. This triangulation, called the Ranchi Secondary Series, is based on the side Gorgabaru (I)-Dalma (IV) of the South Parasnath, and, extending through 13 triangles, closes on a side of the Sambalpur Meridional Series.

Some difficulty was experienced at the commencement of operations, in breaking off from the principal series, owing to the unfavourable nature of the country. As in the case of the Sambalpur Principal work, thickly wooded plateaux made the selection of stations somewhat difficult. The greater part of the series, however, lay in more easy country.

The number of stations observed was	13
" " newly fixed	11
" " built	11
Length of triangulation completed	100
Area of triangulation in sq. miles	988
Theodolites used	T. and S. 8-inch micrometer No. 1055. Cook's 8-inch micrometer No. 10163.
Number of triangles observed	13
Maximum triangular error	6″·34
Average " "	2″·17
Mean closing error in latitude	0″·03
" " longitude	0″·03
" " height	22 ft.
" " azimuth	1″·4
" " log side, (the unit being the seventh decimal place)	124

Bhīr Series.—This Secondary Series, along the parallel of 19°, emanates from the side Dhaigaon (XXXIV)-Maturi (XXXIII) of the Khanpisura Series and closes on the side Somtana (XXXIV)-Shivalingapa (XXXVI) of the Great Arc.

The detachment under Mr. F. W. Smith, with Mr. Norman as assistant, reached Ahmadnagar on 17th October. Mr. Smith took charge of the work of selecting and building stations and, after repairing the two base stations on the Khanpisura Series, pushed out eastwards, establishing stations closing the series on the Great Arc; thence extending still further eastwards, he selected and built thirteen more stations carrying the Bhīr Secondary work as far as the Jabalpur Meridional Series.

Mr. Norman, in the meantime, succeeded in completing the observations over the 24 triangles between the Khanpisura and Great Arc Series.

No particular difficulties were encountered. The series was carried through the northern tract of the Hyderābād State where the topographical features lend themselves readily to triangulation.

During the season a slight outbreak of cholera occurred in the detachment, but matters were kept well in hand by Mr. Norman, who, taking prompt and effective measures, succeeded in stamping out the disease.

The outturn of this detachment was most creditable.

The details of the work are :—

Number of stations observed	26
" " newly built	22
" " built	35
Length of triangulation completed in miles	176
Length of triangulation still to be completed	80
Area of triangulation in sq. miles	2,764
Theodolite used	T. and S. 8-inch micrometer No. 1315.
Number of triangles observed	24
Maximum triangular error	3″·72
Average " "	0″·93
Mean closing error in latitude	0″·18
" " longitude	0″·15
" " height	14 ft.
" " azimuth	1″·27
" " log side, (the unit being the seventh decimal place)	180

Villupuram Series.—This is a Secondary Longitudinal Series lying along the parallel of 12° between the meridians of 77° 50′ and 79° 20′. It emanates from the side Guttirayan (LX)-Karadigutta (LXII) of the Great Arc and, extending through 18 triangles, closes on the side Kiliyur (IX)-Mallipat (VII) of the South-East Coast Series.

The detachment employed was under Mr. Abdul Hai, Sub-Assistant Superintendent, assisted by Mr. Gopalachari till the middle of March 1912.

During November 1911, the two base stations on the Great Arc were repaired and five new stations built. Observations were then commenced at Guttirayan H. S. on 21st December, and from this date building and observing went on concurrently till 4th April when observations were completed at Mallipat, closing the secondary triangulation on the side of the South-East Coast Series.

On 9th April Mr. Abdul Hai was ordered to join the Kashmir Detachment and on 14th of the same month the Villupuram Detachment was disbanded.

Number of stations observed	20
" " newly fixed	16
" " built	16
Length of triangulation completed	99
Area of triangulation in sq. miles	1,106
Theodolite used	T. and S. 8-inch micrometer No. 1311.
Number of triangles observed	18
Maximum triangular error	4″·05
Average " "	1″·77
Mean closing error in latitude	0″·06
" " longitude	0″·06
" " height	6 ft.
" " azimuth	3″·73
" " log side, (the unit being the seventh decimal place)	38

Madura Series.—In the middle of March Mr. Gopalachari, who had till then been Mr. Abdul Hai's assistant in the Villupuram Detachment, was ordered to form his building section into a detachment to be named

the Madura Detachment and moving to Madura, commence the building of stations for a secondary series along the parallel of 10° from the Great Arc to the South-East Coast Series. By the end of June, all but the last two stations of the series had been selected and built. The final selection of these two remaining stations will depend on the side of the South-East Coast Series chosen for the secondary triangulation to close upon.

This side of closure has not yet been decided upon. The question of how the secondary work shall join up to the principal series is somewhat difficult of solution, as satisfactorily clear rays are not easy to obtain through the thick belts of palmyra palms which exist, and further consideration on the spot is required before a final scheme is drawn up.

The detachment returned from the field in the beginning of July 1912.

Bombay Triangulation.—During 1911-12 this Party took up the work of executing a network of points covering the city and island of Bombay, on which to base a large scale detail survey. 125 points have been marked on the ground in a manner which will ensure their permanency and, at the same time, permit of easy reference.

The scheme of work included the connection of these points to the principal triangulation. The most convenient available side of the Bombay Longitudinal series on which to base the network was the secondary ray Bombay, Colāba, S.—Karanja H. S. On this a pentagon with a central station has been constructed, covering the whole of the island and affording bases from which the network may extend.

It had been hoped that by far the greater number of the points of the network could be fixed by triangulation, tall masts suitably guyed being used as signals. Much difficulty has, however, been experienced in obtaining a suitable mast which will permit of erection in the city, and recourse must be had to traversing to fix some 60 to 70 points.

Mr. Collins and Mr. Wainright, in succession, had charge of the detachment employed on this work from the first week of January till the first week of May. During this time, the main pentagon was connected with the principal triangulation and observations were made from 54 subsidiary points, the signals being luminous in the main and opaque in most of the subsidiary figures.

The instrument used was an 8-inch micrometer, (No. 1316 by Messrs. Troughton and Simms).

EXTRACTS FROM LETTERS
FROM THE LATE LIEUTENANT H. G. BELL, R.E.

"*Bandipur, May 17th 1912.*—To-morrow morning early, I start off on my " northward way. Everything is as ready as it can be ; all my loads are made " up and coolies engaged. We are going in two parties, each taking about 120 " coolies. The first pass is open for ponies ; of the second I have no certain " news."

" *May 21st.*—Since leaving Bandipur, I have been through all sorts of " trials and tribulations. I got away from Bandipur in fine weather, and rode " up the zig-zag ascent to Tragbal Bungalow, height about 9,000 feet. There " was still some snow round the bungalow and in the evening it rained. Early " in the morning I got everything packed up and we started off to cross the " Tragbal pass, 11,700 feet. It is quite an easy pass, but it is a bad place to

"get caught in a storm. It started to snow just as we got over the pass, and "in the valley below it was pouring with rain. I found the bungalow in a "sorry state, only two rooms were habitable; the others and most of the out-"houses have been carried away by an avalanche. Luckily it cleared up soon "after we arrived and we were all able to dry ourselves. Next day was fairly "fine and I went down to Gurai valley and then along the Kishenganga valley "to Gurais. There I had to change my ponies for coolies, so the loads had to "be rearranged."

From Gurais to Burzil, the march was apparently slow and troublesome. The coolies had not yet settled down to routine and the distribution and adjustment of loads was not effected without some trouble.

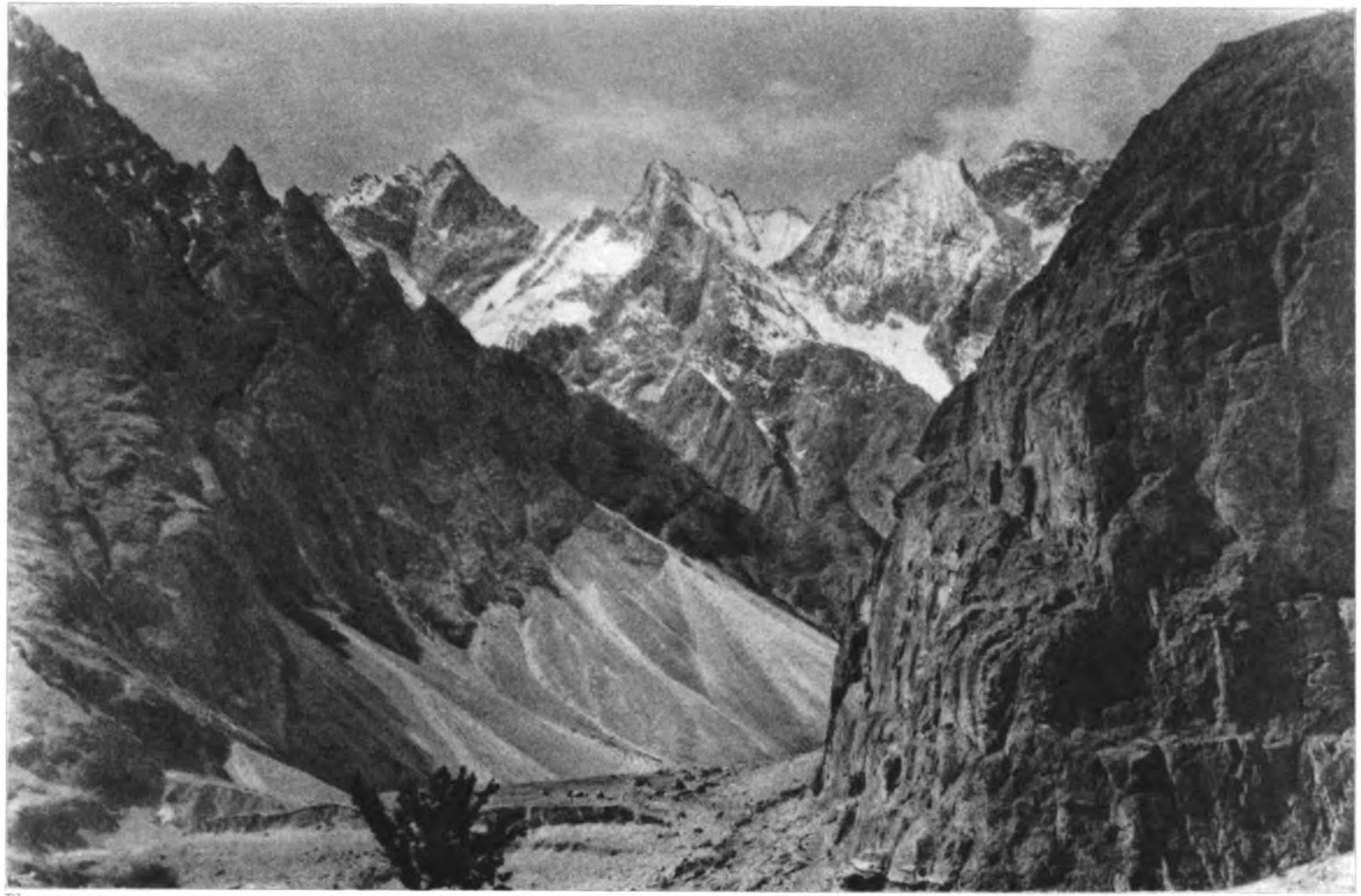
"We reached Burzil about 3 P.M., the last few miles being over the snow. "The bungalow itself was quite surrounded by it. Once more I had to re-"arrange the loads and get everything ready for an early start on the morrow. "We all got off before 3 A.M. and started the ascent of the pass by lantern light. "Over the snow, I toiled along after the coolies and got up to the top of the "pass by 8 A.M. just as it began to snow. The descent to Chillum is long but "gradual and we got there by 4 P.M. in pouring rain and snow. At Chillum "I had again to change my coolies for ponies, so I paid off the coolies and "once more made up pony loads. Next morning it was snowing very hard, so "I decided not to march that day and sent the ponies down the valley to get "food and shelter. Next morning it was beautifully fine but the ponies which "I had ordered did not turn up. A few came in the morning, the rest did not "come till 4 P.M. So I left my assistant there and came on with what ponies "there were. It soon began to snow again and then it got dark. The road "was strewn with boulders that had lately come down the khud, and some were "still falling. However, I went on in practical darkness, running across the "bad places to avoid falling rocks; one only missed me by a few yards. Several "of the ponies died of exposure, chiefly owing to the carelessness of their owners "who left them in the snow without any covering or food.

"Eventually I reached Godhai bungalow at 9-30 P.M. The majority of "the ponies arrived a short time after.

"I left Godhai at 11 A.M. and got here, (Astor), another 17 miles march "by 5-30 P.M. The scenery along this last march is very grand. In one place, "the road passes through a deep and narrow rocky gorge and from above "it one gets a peep at my old friend Nanga Parbat. To-day I halted to let "my assistants catch me up. They got in in the afternoon. The road in "front is badly broken, so there is not much chance of getting on "just yet. I don't know what has become of the other half of my detachment, "which should be two days behind me. I can't find out as the telegraph line "has been broken for three days. The weather has been awful for this time "of the year and has quite upset my plans. I hope to leave here to-morrow or "the day after, so I ought to be in Gilgit before the end of the month."

Bell reached Gilgit on May 28th. Owing to the recent rain, the heat in the Indus valley was not as great as usual and apparently no troubles were met with beyond those incidental to long marches and bad roads.

Between May 28th and June 4th, Bell was occupied in organising his detachment for its work in the Kanjut valley. This was no easy matter and seems to have caused a good deal of worry. On June 4th he wrote, "It has been "a great difficulty arranging supplies for my whole party and now my men are



Photogravure

Survey of India Offices, Calcutta, 1913.

THE HUNZA GORGE BETWEEN GILGIT AND CHALT

" all dissatisfied and giving me a lot of trouble because in a place like this, where " food is scarce, it is impossible to buy a large quantity at the usual bazaar rate. " It is getting quite hot here. I shall be glad to get away to a cooler climate." In this same letter he mentions that on the day after his arrival in Gilgit he had been in bed with severe stomachic pains which he put down to bad water which, he thought, he must have drunk somewhere.

On June 4th, making an early start, Bell with one of his assistants marched 18 miles to Nomal in the Hunza valley. He seems to have been greatly rejoiced by the greenness of this village, well irrigated and cultivated in the midst of a barren forbidding country. On the succeeding days, he marched to Chalt, Hindi, and Baltit, which he reached on the 7th. Of his arrival at Baltit he wrote—" Marched from Hindi to Baltit, the residence of the Mīr of " Hunza: quite a pleasant ride through a succession of villages. A few miles out " we were met by the Mīr's younger son. On our arrival, we found a tent " pitched for us in the Mīr's garden and presently he, his Waẓīr and his eldest " son came to welcome us."

On 8th he stayed at Baltit, dismissing his pony transport and re-arranging the loads for coolies.

On 9th June, " though we were up very early, it was 7 A.M. before we " got all our loads packed on to the coolies and started off, a task made all the " more difficult as we had to do everything through interpreters. The Mīr came " to see us off and we started on foot as the made road stops here, and there is " only a track winding up and down the precipices, no road for a nervous traveller, as it consists in many places of very kutcha built galleries hanging over " the precipices and a false step means a fall of several hundred feet. This " evening we camped in a flat place by the river, the village of Atābād being in " the hills above.

" 10th. We continued our march to Gulmit, the road being rather worse " than yesterday and the heat on the hillside rather trying. We camped in an " orchard of apricot trees and were much worried by flies.

" 11th. This morning our departure was delayed somewhat by our having " to change some of the coolies. However we only had a short and easy march " to Pasu, a village near a big glacier.

" 12th. We left Pasu early, and had to cross the Batur glacier which took " us about an hour climbing up and down the masses of dirty black ice, " bestrewn with all sorts of débris. We breakfasted on the glacier and continued " our march to Khaiber, another small village where we met the hero of hundred " fights, a very cheery old man aged about a hundred.

" 13th. To-day, we did another easy march, crossing the river by quite a " decent bridge and camped at the village of Sost. We had a bad storm in the " afternoon and the dust got blown into everything. The Mīr's brother came " to see me in the afternoon and I had a fairly long talk with him.

" 14th. It was raining slightly very early this morning but soon cleared up " and we started off. Soon we had to ford the river, rather a perilous proceeding. " We had two ponies on which several of us got across but the coolies had to wade. " However they all got over safely though they were nearly washed away. The " track was very bad along this march; in places it went along steep cliffs with " very little foothold. In the afternoon we reached Misgar, the last village in " British territory.

"15th. This morning we sent the main camp on to Murkushi and started "to climb a hill above Misgar with just enough kit for the two of us for one "night. We got up above the snow line by about 3 P.M., and camped there. "In the evening we both had bad headaches and did not eat much dinner.

"16th. It was snowing when we got up but we climbed still higher and "reached one peak only to find another still higher in front of us. The coolies "had got behind. I had to go back to fetch them. Thus we went on a little "further and came to such steep cliffs that we could not get up there with all "the fresh snow about, so we gave it up and came back to camp; packed up and "came down to Misgar. There we got ponies and rode on here, (Murkushi), "arriving about 5 P.M.; a very strenuous day. We were on the move for 12 "hours with barely a rest."

On 17th. They halted at Murkushi to reassemble their kit and to ration the coolies. On the following day, they marched to Gul Khwāja at the foot of the Mintaka pass in a snow storm which, however, stopped in time to allow of tents being pitched and camp established "in the dry." In the afternoon Bell went out in the hope of securing an ibex head, but without success. On 19th, the party crossed the Mintaka pass. "Again the track was very "bad, and gave no end of trouble. One yak went over backwards and was only "saved from an untimely end by several of us holding on to his horns till his "load was cut loose. We crossed the Mintaka pass in a snow storm about 12 "noon, leaving British India behind and entering Chinese Turkistan and the "'Roof of the World.' The descent on this side brought us down into a wide "open valley covered with green grass where lots of yaks were grazing. We "followed the valley down a long way till we reached an encampment where "we were ushered into a 'yart', a round dome-shaped wooden framework "covered with felt, draped with embroidery inside and carpeted with thick "rugs where tea and sweets were brought to us. The Sarakoulis are fine big "men, very cheery and good looking. Clothed in their many wadded coats, "long boots and fur caps they look very picturesque. They certainly are most "hospitable. They keep one 'yart' always ready for guests. Some of our "kit did not arrive till after dark owing to the difficulties of the road and the "bad weather.

"20th. We stayed in camp to-day as it was very cold and stormy; re-"packed our kit and prepared to separate on the morrow. Several headmen "came to see me and I had to give them tea and entertain them."

On 21st Bell moved towards Beyik while his assistant, Mr. McInnes, turned off towards the Karchanai pass. The next day Beyik pass was reached and the two Russian triangulation stations located, the camp being established in a small open valley at the foot of the pass. On 23rd, he had a stiff climb to the eastern survey point in a snow storm. By the time he had reached the summit, however, the weather had cleared and he got a view all round. He remarked that the Pamīrs on the far side were much lower than those he had crossed and the mountains quite insignificant.

On 24th, he moved camp down the nullah back to Beyik, going out in the afternoon to select his first station. He also wrote a letter, in French, to the Russian Survey Officer, whom he thought to be encamped at Kizil Rabāt. He learnt later that, though expected, this officer had not yet arrived.

On 25th, he moved his camp into a small nullah close under his first station.

Photogravure

Survey of India Offices, Calcutta, 1913.

GRAPHIC SIGNAL USED BY THE RUSSIAN TRIANGULATION PARTY ON THE TAGHDUMBASH PAMIR

He writes on 27th,—"We had more snow last night, but it cleared up in "the morning and I moved up the nullah north of my camp and climbed up a "long way and pitched my small tent in a very damp and cold spot, the only "more or less flat one available.

"28th. Up at sun rise; moved further up the nullah and got on the "ridge; went along its knife-like edge to a more or less flat place where I "put up a signal station. A fine sunny day but even then my feet got nearly "frozen with the cold. I stayed up there some time and then came down to my "main camp; a long descent from 17,000 to 12,000 feet. On my arrival, I "found McInnes there. After consultation, we decided to give up the scheme "of the Karchanai pass and try to go round by the Kilik."

On 29th, camp was moved again up the Beyik nullah towards the western Russian point. The weather had improved, for Bell remarks that it seemed "to have changed for the better at last." On July 3rd, he was again at his first station about to commence observing. On this day he was not in camp till 9-30 P.M., for after completing the march, he went out after ovis poli. He secured one head but the stalk had taken him a long way from camp. "By "the time we had cut his head off, it was dark and we had a long trek back "to camp and an icy cold stream to cross. However I got there by 9-30 P.M. "hungry and weary but elated and was up by 6 next morning."

On July 4th, Bell commenced observing under difficulties; a high wind was blowing and snow began to fall, and it was not till the next day that he managed to get work at this station finished, moving down afterwards to his main camp.

On July 6th, we "climbed up the Russian west station and found the "Russian signal deep in snow. However with twelve men and a bucket "and phowrah we cleared away 10 feet of snow all round it and pitched the ob-"servatory tent and made a platform for our tents. In the evening it started to "blow and snow.

"July 7th, I did observations and spent the rest of my time cooking my "food, for when I go up to the stations, I can't take my cook as I have only "twelve coolies to take up my own and my babu's kit, etc."

On 8th, he finished work and moved back to his main camp, going out in the evening after poli again but failing to get a shot.

The next day Bell went over to the Russian Survey camp, where he was received by the Russian Officers, a Colonel, a Captain and a Lieutenant, and entertained in a "yart."

He wrote—"We were very merry and they most hospitable. I had to "write my name in their pocket books and they in mine. Then we adjourned "to photograph each other and returned for more refreshment. Then they "escorted me back to the pass and we parted the best of friends.

"So now I have been into three empires this season and to the most "northern point the Survey of India has reached."

On 10th and 11th, he prepared the Russian eastern point to receive his observatory tent, finished observations there and came down to his main camp. On 11th, he wrote "I am very fit and have quite got my mountain "legs and feel full of work."

From this station, Bell marched back towards the Mintaka pass, to his last camp at Lup Gaz.

PART IV.—TIDAL OPERATIONS.

No. 16 PARTY.

(*Vide* Index Map 10.)

BY MR. H. G. SHAW.

PERSONNEL.

Imperial Officer.

Major J. M. Burn, R.E., in charge till 27th October 1911.

Provincial Officers.

Mr. H. G. Shaw, in charge from 28th October 1911.

Mr. Syed Zille Hasnain.

Lower Subordinate Service.

1 Clerk.
16 Computers.
2 Artificers.
2 Tidal Observatory clerks.

The personnel of the party was as shown in the margin. Two computers died during the year under report, otherwise the health of the members of the party was good.

The recording of the tidal curves by self-registering tide-gauges was continued during the past year at the following ports:—

Aden, Karāchi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair.

The work was carried out under the direction of this department, but the immediate control of the tidal observatories rested with the Port Officers concerned.

In addition to the automatic tidal registrations at the above ports, readings of high and low water were undertaken during daylight on tide-poles at Bhāvnagar and Akyab, with the object of checking the predicted times and heights. Till the end of the year 1910 similar readings were also taken at Chittagong; but they were discontinued from 1st January 1911, and in their place the Port Officer of Chittagong supplied to this office diagrams recorded by a small self-registering river gauge. These diagrams, however, could not serve the purpose of checking the predicted times and heights at Chittagong, as readings obtained from them were not satisfactory, chiefly owing to the very small scale on which the tidal curves were registered.

LIST OF TIDAL STATIONS.

The following is a complete list of the ports at which tidal observations have been carried out from the commencement of tidal operations in 1874 up to the present time. The stations shown in italics are permanent, the others being minor stations where tidal observatories were closed on the completion of the requisite registrations:—

Serial No.	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
1	Suez	Automatic	1897	1903	7	
2	Perim	Ditto	1898	1902	5	
3	*Aden*	Ditto	1879	Still working	33	
4	Maskat	Ditto	1893	1898	5	
5	Bushire	Ditto	1892	1901	8	
6	*Karāchi*	Ditto	1868 1881	1880 Still working	*13 32 } 45	* Small Tide-gauge working.
7	Hanstal	Ditto	1874	1875	1	Tide-Tables not published.

Serial No.	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
8	Navānar	Automatic	1874	1875	1	Tide-Tables not published.
9	Okha Point	Ditto	1874	1875	1 } 2	Year 1904-05 is excluded.
			Re-started 1904	1906	1	
10	Porbandar	Personal	1893	1894	2	
10A	Porbandar	Automatic	1898	1902	2	Years 1898, 1899 and 1902 are excluded.
11	Port Albert Victor (Kathiawār).	Personal	1881	1882	1	
11A	Port Albert Victor (Kathiawār).	Automatic	1900	1903	4	
12	Bhāvnagar	Ditto	1889	1894	5	
13	*Bombay (Apollo Bandar).*	Ditto	1878	Still working	34	
14	*Bombay (Prince's Dock).*	Ditto	1888	Ditto	24	
15	Marmagāo (Goa)	Ditto	1884	1889	5	
16	Kārwār	Ditto	1878	1883	5	
17	Beypore	Ditto	1878	1884	6	
18	Cochin	Ditto	1886	1892	6	
19	Tuticorin	Ditto	1888	1893	5	
20	Minicoy	Ditto	1891	1896	5	
21	Galle	Ditto	1884	1890	6	
22	Colombo	Ditto	1884	1890	6	
23	Trincomalee	Ditto	1890	1896	6	
24	Pāmban Pass	Ditto	1878	1882	4	
25	Negapatam	Ditto	1881	1888	5	Years 1883, 1884, 1885 are excluded.
26	*Madras*	Ditto	1880	1890	10 } 27	
			Re-started 1895	Still working	17	
27	Cocanāda	Ditto	1886	1891	5	
28	Vizagapatam	Ditto	1879	1885	6	
29	False Point	Ditto	1881	1885	4	
30	Dublat (Sāgar Island)	Ditto	1881	1886	5	
31	Diamond Harbour	Ditto	1881	1886	5	
32	*Kidderpore*	Ditto	1881	Still working	31	
33	Chittagong	Ditto	1886	1891	5	
34	Akyab	Ditto	1887	1892	5	
35	Diamond Island	Ditto	1895	1899	5	
36	Bassein (Burma)	Ditto	1902	1903	2	
37	Elephant Point	Ditto	1880	1881 }	5	Year 1880-81 is excluded.
			Re-started 1884	1888		
38	*Rangoon*	Ditto	1880	Still working	32	
39	Amherst	Ditto	1880	1886	6	
40	*Moulmein*	Ditto	1880	1886	6 } 9	
			Re-started 1909	Still working	3	
41	Mergui	Ditto	1889	1894	5	
42	*Port Blair*	Ditto	1880	Still working	32	

The tidal observatories at Port Blair, Rangoon, Moulmein, Kidderpore and Madras were inspected by Mr. H. G. Shaw, and those at Apollo Bandar (Bombay), Princes' Dock (Bombay), Karāchi and Aden by Mr. Syed Zille Hasnain. The tide-gauges and other instruments at all the observatories were thoroughly overhauled, cleaned and put in perfect working order. The relative levels of the bed-plates of the tide-gauges were also tested with the bench-marks of reference.

WORKING OF THE OBSERVATORIES.

The following account gives details of the working of the several observatories:—

Aden.—The tide-gauge at this observatory has worked well during the past year. There were a few minor interruptions in the tidal registrations owing to the stoppage of the driving clock.

Karāchi.—The tide-gauge and auxiliary instruments have worked uninterruptedly during the year under report. At the time of the inspection of this observatory a good deal of mud was found to have accumulated on the outside of the bottom of the cylinder and the communication hole was partly blocked.

The inspecting officer had the mud thoroughly cleared with the assistance of a diver, and free communication between the sea and the cylinder was restored.

Apollo Bandar (Bombay).—The tide-gauge has worked well throughout the year. There have been no breaks in the tidal registrations.

Prince's Dock (Bombay).—There have been several minor interruptions in the working of the tide-gauge at this observatory, the cause being either the stoppage of the driving clock or the breaking of the pencil wire.

The latter has always been found to be a frequent source of trouble with this tide-gauge.

Madras.—There have been no interruptions in the registration of the tide at this observatory during the past year. The new sluice fixed in the well last year was found to be in perfect working order at the time of the inspection of this observatory. A little water was discovered to have found its way into the float, which was thoroughly repaired and put in good order again.

Kidderpore.—The tidal registrations at this observatory have been carried out without a break during the past year. This being a riverain port there is a great tendency for mud to collect round the bottom of the cylinder frequently. But arrangements have been made by the Deputy Conservator of the port to have the necessary dredging carried out at short intervals and thus to maintain free communication between the river and cylinder.

Rangoon.—With the exception of a few minor interruptions in the registrations, the tide-gauge and the auxiliary instruments have worked well throughout the year.

Moulmein.—The tide-gauge at this observatory worked well during the past year; there was a break in the registrations of over eleven days' duration in August 1912. The driving clock stopped early in the morning of 4th August and could not be repaired and restarted before the afternoon of the 5th idem.

When tidal observations were taken at Moulmein between the years 1880-86, it appeared that the configuration of the land had a remarkable effect on the tides.

It was found that at the wharf where observations were taken, the water, although rising higher at spring tides than at neaps, fell lower at neaps than at springs. The above peculiarity of the tides at Moulmein is still noticeable, as shown from the tidal registrations taken since the observatory was re-started in 1909. The new observatory stands practically on the site of the old one.

Port Blair.—The tide gauge and the auxiliary instruments at this observatory have worked well throughout the year. There have been no breaks in their registrations.

Computations and Reduction of Observations.

All the computations pertaining to the season's work have been completed and there are no arrears. The tidal observations for the year 1911 have been reduced by harmonic analysis and the tabulated values of the tidal constants thus determined are herewith appended.

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TIDAL CONSTANTS.

The following tables give the amplitudes (R) and the epochs (ζ) deduced from the 1911 observations at the various stations; they also give the values of H and κ which are connected with R and ζ in such a way, through the various astronomical quantities involved in the positions of the sun and moon, that if the tidal observations were consistent from year to year, H and κ would come out the same from each year's reductions:—

ADEN, 1911.

Short Period Tides.

A_0 = 5·768 feet.

S_1	H = R =	·097	M_6	R =	·003	Q_1	R =	·175	T_2	R =	·077
	$\kappa = \zeta$ =	180°·36		ζ =	95°·71		ζ =	118°·61		ζ =	249°·27
S_2	H = R =	·676		H =	·004		H =	·151		H =	·077
	$\kappa = \zeta$ =	244°·97		κ =	21°·90		κ =	41°·12		κ =	250°·79
S_4	H = R =	·007	M_8	R =	·001	L_2	R =	·051	$(MS)_4$	R =	·011
	$\kappa = \zeta$ =	272°·56		ζ =	102°·53		ζ =	208°·96		ζ =	178°·39
S_6	H = R =	·004		H =	·001		H =	·041		H =	·012
	$\kappa = \zeta$ =	225°·00		κ =	4°·11		κ =	226°·84		κ =	153°·79
S_8	H = R =	·000	O_1	R =	·771	N_2	R =	·403	$(2SM)_2$	R =	·012
	$\kappa = \zeta$ =	206°·57		ζ =	246°·03		ζ =	115°·71		ζ =	100°·83
				H =	·668		H =	·416		H =	·012
				κ =	38°·15		κ =	221°·49		κ =	125°·43
M_1	R =	·094	K_1	R =	1·438	λ_2	R =	...	$2N_2$	R =	·078
	ζ =	89°·08		ζ =	210°·01		ζ =	...		ζ =	322°·37
	H =	·075		H =	1·313		H =	...		H =	·080
	κ =	51°·16		κ =	35°·20		κ =	...		κ =	198°·53
M_2	R =	1·518	K_2	R =	·237	ν_2	R =	·027	$(M_2N)_4$	R =	·013
	ζ =	251°·73		ζ =	48°·12		ζ =	16°·12		ζ =	162°·31
	H =	1·564		H =	·189		H =	·028		H =	·014
	κ =	227°·12		κ =	237°·99		κ =	197°·82		κ =	243°·48
M_3	R =	·017	P_1	R =	·425	μ_2	R =	·050	$(M_2K_1)_3$	R =	·015
	ζ =	254°·78		ζ =	222°·29		ζ =	235°·82		ζ =	78°·31
	H =	·018		H =	·425		H =	·053		H =	·014
	κ =	217°·87		κ =	32°·39		κ =	186°·62		κ =	238°·90
M_4	R =	·010	J_1	R =	·139	R_2	R =	...	$(2M_2K_1)_3$	R =	·007
	ζ =	36°·49		ζ =	329°·11		ζ =	...		ζ =	207°·65
	H =	·010		H =	·122		H =	...		H =	·007
	κ =	347°·28		κ =	22°·01		κ =	...		κ =	333°·25

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·030	66°·28	·033	295°·90
„ Fortnightly „	·065	157°·71	·047	8°·36
Luni-Solar „ „	·012	306°·13	·012	330°·73
Solar-Annual „ .	·378	65°·06	·378	344°·96
„ Semi-Annual „ . .	·124	285°·43	·124	125°·22

KARĀCHI, 1911.

Short Period Tides.

$A_0 = 7{\cdot}223$ feet.

S_1 $H = R =$	·102	M_6 $R =$	·040	Q_1 $R =$	·178	T_2 $R =$	·118
S_1 $\kappa = \zeta =$	194°·42	M_6 $\zeta =$	266°·37	Q_1 $\zeta =$	128°·14	T_2 $\zeta =$	325°·00
S_2 $H = R =$	·966	M_6 $H =$	·044	Q_1 $H =$	·154	T_2 $H =$	·118
S_2 $\kappa = \zeta =$	323°·29	M_6 $\kappa =$	197°·02	Q_1 $\kappa =$	52°·99	T_2 $\kappa =$	326°·58
S_4 $H = R =$	·011	M_8 $R =$	·004	L_2 $R =$	·084	$(MS)_4$ $R =$	·034
S_4 $\kappa = \zeta =$	11°·61	M_8 $\zeta =$	58°·74	L_2 $\zeta =$	282°·77	$(MS)_4$ $\zeta =$	335°·47
S_6 $H = R =$	·007	M_8 $H =$	·005	L_2 $H =$	·068	$(MS)_4$ $H =$	·035
S_6 $\kappa = \zeta =$	302°·54	M_8 $\kappa =$	326°·27	L_2 $\kappa =$	301°·34	$(MS)_4$ $\kappa =$	312°·35
S_8 $H = R =$	·002	O_1 $R =$	·779	N_2 $R =$	·583	$(2SM)_2$ $R =$	·014
S_8 $\kappa = \zeta =$	47°·29	O_1 $\zeta =$	253°·82	N_2 $\zeta =$	169°·57	$(2SM)_2$ $\zeta =$	106°·34
		O_1 $H =$	·674	N_2 $H =$	·601	$(2SM)_2$ $H =$	·015
		O_1 $\kappa =$	47°·49	N_2 $\kappa =$	277°·64	$(2SM)_2$ $\kappa =$	129°·46
M_1 $R =$	·093	K_1 $R =$	1·452	λ_2 $R =$	...	$2N_2$ $R =$	·064
M_1 $\zeta =$	108°·01	K_1 $\zeta =$	221°·17	λ_2 $\zeta =$	...	$2N_2$ $\zeta =$	8°·13
M_1 $H =$	·075	K_1 $H =$	1·326	λ_2 $H =$	...	$2N_2$ $H =$	·066
M_1 $\kappa =$	70°·82	K_1 $\kappa =$	46°·30	λ_2 $\kappa =$	...	$2N_2$ $\kappa =$	247°·38
M_2 $R =$	2·528	K_2 $R =$	·343	ν_2 $R =$	·036	$(M_2N)_4$ $R =$	·017
M_2 $\zeta =$	316°·89	K_2 $\zeta =$	127°·62	ν_2 $\zeta =$	54°·74	$(M_2N)_4$ $\zeta =$	247°·08
M_2 $H =$	2·600	K_2 $H =$	·273	ν_2 $H =$	·037	$(M_2N)_4$ $H =$	·018
M_2 $\kappa =$	293°·77	K_2 $\kappa =$	317°·38	ν_2 $\kappa =$	238°·62	$(M_2N)_4$ $\kappa =$	332°·03
M_3 $R =$	·037	P_1 $R =$	·425	μ_2 $R =$	·044	$(M_2K_1)_3$ $R =$	·031
M_3 $\zeta =$	16°·14	P_1 $\zeta =$	233°·21	μ_2 $\zeta =$	322°·47	$(M_2K_1)_3$ $\zeta =$	167°·12
M_3 $H =$	·039	P_1 $H =$	·425	μ_2 $H =$	·047	$(M_2K_1)_3$ $H =$	·029
M_3 $\kappa =$	341°·47	P_1 $\kappa =$	43°·38	μ_2 $\kappa =$	276°·24	$(M_2K_1)_3$ $\kappa =$	329°·14
M_4 $R =$	·018	J_1 $R =$	·132	R_2 $R =$	...	$(2M_2K_1)_3$ $R =$	·029
M_4 $\zeta =$	18°·86	J_1 $\zeta =$	342°·57	R_2 $\zeta =$	...	$(2M_2K_1)_3$ $\zeta =$	227°·18
M_4 $H =$	·019	J_1 $H =$	·116	R_2 $H =$	...	$(2M_2K_1)_3$ $H =$	·028
M_4 $\kappa =$	332°·63	J_1 $\kappa =$	34°·60	R_2 $\kappa =$	...	$(2M_2K_1)_3$ $\kappa =$	355°·81

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·029	121°·04	·032	349°·85
„ Fortnightly „	·031	179°·49	·023	29°·04
Luni-Solar „ „ . . .	·003	120°·12	·003	143°·23
Solar-Annual „	·112	163°·82	·112	83°·66
„ Semi-Annual „	·068	5°·99	·068	205°·66

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BOMBAY (APOLLO BANDAR), 1911.

Short Period Tides.

A_0=10·190 feet.

S_1	H = R =	·072	M_6	R =	·014	Q_1	R =	·171	T_2	R =	·209
	κ = ζ =	201°·21		ζ =	117°·16		ζ =	131°·46		ζ =	11°·05
S_2	H = R =	1·554		H =	·016		H =	·148		H =	·209
	κ = ζ =	3°·76		κ =	49°·01		κ =	56°·94		κ =	12°·64
S_4	H = R =	·017	M_8	R =	·012	L_2	R =	·073	$(MS)_4$	R =	·080
	κ = ζ =	221°·86		ζ =	85°·19		ζ =	315°·34		ζ =	48°·36
S_6	H = R =	·003		H =	·013		H =	·059		H =	·082
	κ = ζ =	166°·37		κ =	354°·31		κ =	334°·09		κ =	25°·64
S_8	H = R =	·003	O_1	R =	·756	N_2	R =	·915	$(2SM)_2$	R =	·037
	κ = ζ =	143°·97		ζ =	255°·13		ζ =	206°·45		ζ =	73°·77
				H =	·655		H =	·943		H =	·038
				κ =	49°·22		κ =	315°·12		κ =	96°·49
M_1	R =	·106	K_1	R =	1·512	λ_2	R =	...	$2N_2$	R =	·054
	ζ =	109°·52		ζ =	220°·62		ζ =	...		ζ =	43°·04
	H =	·085		H =	1·380		H =	...		H =	·056
	κ =	72°·53		κ =	45°·73		κ =	...		κ =	283°·11
M_2	R =	3·862	K_2	R =	·519	ν_2	R =	·066	$(M_2N)_4$	R =	·014
	ζ =	353°·44		ζ =	164°·92		ζ =	51°·18		ζ =	174°·04
	H =	3·979		H =	·413		H =	·068		H =	015
	κ =	330°·72		κ =	354°·64		κ =	235°·64		κ =	259°·99
M_3	R =	·074	P_1	R =	·420	μ_2	R =	·166	$(M_2K_1)_3$	R =	·053
	ζ =	53°·93		ζ =	233°·39		ζ =	354°·31		ζ =	107°·38
	H =	·077		H =	·420		H =	·177		H =	·050
	κ =	19°·85		κ =	43°·57		κ =	308°·87		κ =	269°·78
M_4	R =	·097	J_1	R =	·139	R_2	R =	...	$(2M_2K_1)_3$	R =	·070
	ζ =	351°·36		ζ =	346°·88		ζ =	...		ζ =	293°·21
	H =	·103		H =	·122		H =	...		H =	·068
	κ =	305°·93		κ =	38°·68		κ =	...		κ =	62°·66

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·035	57°·09	·039	285°·69
„ Fortnightly „	·034	194°·31	·025	43°·42
Luni-Solar „ „	·018	11°·37	·019	34°·08
Solar-Annual „	·157	0°·65	·157	280°·47
„ Semi-Annual „	·153	3°·57	·153	203°·21

BOMBAY (PRINCE'S DOCK), 1911.

Short Period Tides.

$A_0 = 8·198$ feet.

S_1	H = R =	·094	M_6	R =	·011	Q_1	R =	·175	T_2	R =	·216
	κ = ζ =	201°·19		ζ =	222°·47		ζ =	131°·07		ζ =	8°·82
S_2	H = R =	1·599		H =	·012		H =	·151		H =	·216
	κ = ζ =	4°·97		κ =	154°·32		κ =	56°·55		κ =	10°·42
S_4	H = R =	·021	M_8	R =	·007	L_2	R =	·098	$(MS)_4$	R =	·121
	κ = ζ =	199°·49		ζ =	128°·50		ζ =	310°·29		ζ =	67°·68
S_6	H = R =	·004		H =	·008		H =	·079		H =	·125
	κ = ζ =	149°·86		κ =	37°·63		κ =	329°·04		κ =	44°·97
S_8	H = R =	·002	O_1	R =	·768	N_2	R =	·954	$(2SM)_2$	R =	·043
	κ = ζ =	75°·96		ζ =	254°·46		ζ =	207°·52		ζ =	83°·85
				H =	665		H =	·983		H =	·045
				κ =	48°·54		κ =	316°·20		κ =	106°·57
M_1	R =	·112	K_1	R =	1·525	λ_2	R =	...	$2N_2$	R =	·061
	ζ =	107°·46		ζ =	220°·62		ζ =	...		ζ =	44°·47
	H =	·090		H =	1·392		H =	...		H =	·063
	κ =	70°·47		κ =	45°·74		κ =	...		κ =	284°·54
M_2	R =	3·955	K_2	R =	·536	ν_2	R =	·045	$(M_2N)_4$	R =	·011
	ζ =	354°·02		ζ =	164°·93		ζ =	70°·27		ζ =	274°·76
	H =	4·075		H =	·427		H =	·047		H =	·012
	κ =	331°·30		κ =	354°·66		κ =	254°·73		κ =	0°·72
M_3	R =	·077	P_1	R =	·417	μ_2	R =	·181	$(M_2K_1)_3$	R =	·034
	ζ =	60°·15		ζ =	233°·76		ζ =	3°·14		ζ =	85°·18
	H =	·080		H =	·417		H =	·192		H =	·032
	κ =	26°·07		κ =	43°·94		κ =	317°·71		κ =	247°·58
M_4	R =	·099	J_1	R =	·134	R_2	R =	...	$(2M_2K_1)_3$	R =	·085
	ζ =	19°·89		ζ =	346°·32		ζ =	...		ζ =	304°·90
	H =	·105		H =	·117		H =	...		H =	0·082
	κ =	334°·45		κ =	38°·12		κ =	...		κ =	74°·35

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·033	63°·53	·037	292°·13
„ Fortnightly „ . . .	·043	181°·84	·031	30°·96
Luni-Solar „ „ . . .	·029	337°·99	·030	0°·71
Solar-Annual „ . . .	·155	357°·15	·155	276°·97
„ Semi-Annual „ . . .	·144	14°·60	·144	214°·24

MADRAS, 1911.

Short Period Tides.

$A_0 = 2·296$ feet.

S_1	$H = R =$	·031	M_6	$R =$	·002	Q_1	$R =$	·011	T_2	$R =$	·048
	$\kappa = \zeta =$	103°·90		$\zeta =$	176°·63		$\zeta =$	88°·45		$\zeta =$	260°·32
S_2	$H = R =$	·462		$H =$	·002		$H =$	·010		$H =$	·048
	$\kappa = \zeta =$	271°·07		$\kappa =$	109°·99		$\kappa =$	14°·72		$\kappa =$	261°·94
S_4	$H = R =$	·002	M_8	$R =$	·002	L_2	$R =$	·064	$(MS)_4$	$R =$	·005
	$\kappa = \zeta =$	262°·24		$\zeta =$	195°·52		$\zeta =$	234°·55		$\zeta =$	232°·91
S_6	$H = R =$	·002		$H =$	·003		$H =$	·051		$H =$	·006
	$\kappa = \zeta =$	18°·44		$\kappa =$	106°·66		$\kappa =$	253°·53		$\kappa =$	210°·69
S_8	$H = R =$	·001	O_1	$R =$	·107	N_2	$R =$	·223	$(2SM)_2$	$R =$	·024
	$\kappa = \zeta =$	231°·34		$\zeta =$	172°·98		$\zeta =$	124°·37		$\zeta =$	187°·63
				$H =$	·092		$H =$	·230		$H =$	·025
				$\kappa =$	327°·58		$\kappa =$	233°·82		$\kappa =$	209°·84
M_1	$R =$	·013	K_1	$R =$	·327	λ_2	$R =$	...	$2N_2$	$R =$	·039
	$\zeta =$	23°·31		$\zeta =$	152°·08		$\zeta =$	...		$\zeta =$	359°·41
	$H =$	·011		$H =$	·298		$H =$	...		$H =$	·041
	$\kappa =$	346°·57		$\kappa =$	337°·18		$\kappa =$	...		$\kappa =$	240°·52
M_2	$R =$	1·054	K_2	$R =$	·153	ν_2	$R =$	·016	$(M_2N)_4$	$R =$	·006
	$\zeta =$	262°·52		$\zeta =$	79°·14		$\zeta =$	25°·08		$\zeta =$	141°·84
	$H =$	1·086		$H =$	·122		$H =$	·016		$H =$	·006
	$\kappa =$	240°·30		$\kappa =$	268°·82		$\kappa =$	210°·28		$\kappa =$	229°·08
M_3	$R =$	·004	P_1	$R =$	·096	μ_2	$R =$	·021	$(M_2K_1)_3$	$R =$	·013
	$\zeta =$	35°·71		$\zeta =$	166°·04		$\zeta =$	225°·40		$\zeta =$	88°·64
	$H =$	·004		$H =$	·096		$H =$	·022		$H =$	·012
	$\kappa =$	2°·38		$\kappa =$	336°·24		$\kappa =$	180°·97		$\kappa =$	251°·51
M_4	$R =$	·006	J_1	$R =$	·025	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·004
	$\zeta =$	216°·87		$\zeta =$	259°·74		$\zeta =$	...		$\zeta =$	206°·57
	$H =$	·007		$H =$	·022		$H =$	...		$H =$	·004
	$\kappa =$	172°·44		$\kappa =$	311°·25		$\kappa =$	...		$\kappa =$	337°·04

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·057	199°·56	·064	67°·90
„ Fortnightly „	·074	186°·46	·054	35°·03
Luni-Solar „ „	·026	252°·21	·027	274°·42
Solar-Annual „	·382	280°·58	·382	200°·37
„ Semi-Annual „	·306	326°·06	·306	165°·66

KIDDERPORE, 1911.

Short Period Tides.

$A_0 = 10{\cdot}781$ feet.

S_1	H = R =	·090	M_6	R =	·128	Q_1	R =	·032	T_2	R =	·193
	κ = ζ =	196°·43		ζ =	14°·89		ζ =	100°·92		ζ =	123°·70
S_2	H = R =	1·548		H =	·141		H =	·028		H =	·193
	κ = ζ =	96°·46		κ =	309°·89		κ =	28°·06		κ =	125°·34
S_4	H = R =	·095	M_8	R =	·044	L_2	R =	·251	$(MS)_4$	R =	·666
	κ = ζ =	104°·74		ζ =	348°·47		ζ =	40°·66		ζ =	92°·36
S_6	H = R =	·007		H =	·049		H =	·201		H =	·687
	κ = ζ =	90°·81		κ =	261°·80		κ =	59°·90		κ =	70°·69
S_8	H = R =	·001	O_1	R =	·242	N_2	R =	·619	$(2SM)_2$	R =	·090
	κ = ζ =	105°·95		ζ =	226°·63		ζ =	297°·21		ζ =	340°·81
				H =	·210		H =	·638		H =	·092
				κ =	21°·80		κ =	47°·50		κ =	2°·48
M_1	R =	017	K_1	R =	·447	λ_2	R =	...	$2N_2$	R =	·163
	ζ =	306°·94		ζ =	228°·97		ζ =	...		ζ =	120°·37
	H =	·014		H =	·408		H =	...		H =	·168
	κ =	270°·46		κ =	54°·05		κ =	...		κ =	2°·61
M_2	R =	3·586	K_2	R =	·596	ν_2	R =	·153	$(M_2N)_4$	R =	·257
	ζ =	76°·35		ζ =	261°·14		ζ =	173°·69		ζ =	298°·98
	H =	3·695		H =	·475		H =	·157		H =	·273
	κ =	54°·68		κ =	90°·78		κ =	359°·68		κ =	27°·60
M_3	R =	·050	P_1	R =	·152	μ_2	R =	·292	$(M_2K_1)_3$	R =	·155
	ζ =	13°·40		ζ =	234°·14		ζ =	222°·60		ζ =	230°·50
	H =	·052		H =	·152		H =	·310		H =	·146
	κ =	340°·90		κ =	44°·36		κ =	179°·27		κ =	33°·90
M_4	R =	·682	J_1	R =	·040	R_2	R =	...	$(2M_2K_1)_3$	R =	·045
	ζ =	72°·92		ζ =	340°·33		ζ =	...		ζ =	186°·04
	H =	·724		H =	·035		H =	...		H =	·043
	κ =	29°·58		κ =	31°·52		κ =	...		κ =	317°·63

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·283	141°·26	·316	9°·30
" Fortnightly "	·332	199°·54	·242	47°·51
Luni-Solar " "	·913	22°·54	·940	44°·21
Solar-Annual "	2·783	233°·02	2·783	152°·80
" Semi-Annual "	·765	152°·37	·765	351°·92

RANGOON, 1911.

Short Period Tides.

$A_0 = 10·348$ feet.

S_1	H = R =	·150	M_6	R =	·199	Q_1	R =	·055	T_2	R =	·341
	κ = ζ =	129°·75		ζ =	160°·58		ζ =	111°·39		ζ =	156°·18
S_2	H = R =	2·129		H =	·218		H =	·048		H =	·341
	κ = ζ =	171°·16		κ =	97°·18		κ =	39°·36		κ =	157°·83
S_4	H = R =	·097	M_8	R =	·075	L_2	R =	·434	$(MS)_4$	R =	·521
	κ = ζ =	262°·29		ζ =	197°·55		ζ =	115°·77		ζ =	238°·64
S_6	H = R =	·005		H =	·084		H =	·348		H =	·537
	κ = ζ =	49°·76		κ =	113°·01		κ =	135°·26		κ =	217°·50
S_8	H = R =	·004	O_1	R =	·335	N_2	R =	·939	$(2SM)_2$	R =	·166
	κ = ζ =	78°·41		ζ =	224°·78		ζ =	10°·45		ζ =	29°·87
				H =	·290		H =	·967		H =	·171
				κ =	20°·51		κ =	121°·56		κ =	51°·01
M_1	R =	·053	K_1	R =	·734	λ_2	R =	...	$2N_2$	R =	·342
	ζ =	121°·47		ζ =	209°·62		ζ =	...		ζ =	217°·26
	H =	·043		H =	·670		H =	...		H =	·352
	κ =	85°·25		κ =	34°·67		κ =	...		κ =	100°·61
M_2	R =	5·707	K_2	R =	·812	ν_2	R =	·191	$(M_2N)_4$	R =	·211
	ζ =	153°·98		ζ =	335°·34		ζ =	280°·55		ζ =	76°·05
	H =	5·881		H =	·647		H =	·197		H =	·224
	κ =	132°·84		κ =	164°·93		κ =	107°·32		κ =	166°·02
M_3	R =	·024	P_1	R =	·205	μ_2	R =	·528	$(M_2K_1)_3$	R =	·199
	ζ =	131°·74		ζ =	236°·98		ζ =	328°·97		ζ =	283°·86
	H =	·025		H =	·205		H =	·560		H =	·187
	κ =	100°·03		κ =	47°·22		κ =	286°·69		κ =	87°·78
M_4	R =	·544	J_1	R =	·039	R_2	R =	...	$(2M_2K_1)_3$	R =	·145
	ζ =	215°·97		ζ =	352°·91		ζ =	...		ζ =	280°·94
	H =	·577		H =	·034		H =	...		H =	·140
	κ =	173°·70		κ =	43°·80		κ =	...		κ =	53°·62

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·128	155°·68	·143	23°·44
„ Fortnightly „	·211	192°·90	·154	40°·30
Luni-Solar „ „	·518	26°·90	·534	48°·04
Solar-Annual „	1·512	224°·03	1·512	143°·78
„ Semi-Annual „	·195	107°·90	·195	307°·41

MOULMEIN, 1911.

Short Period Tides.

$A_0 = 8·589$ feet.

S_1	$H=R=$	·096	M_6	$R=$	·071	Q_1	$R=$	·055	T_2	$R=$	·239
	$\kappa=\zeta=$	153°·78		$\zeta=$	237°·90		$\zeta=$	137°·83		$\zeta=$	129°·45
S_2	$H=R=$	1·484		$H=$	·078		$H=$	·047		$H=$	·239
	$\kappa=\zeta=$	143°·48		$\kappa=$	174°·79		$\kappa=$	65°·96		$\kappa=$	131°·11
S_4	$H=R=$	·085	M_8	$R=$	·039	L_2	$R=$	·340	$(MS)_4$	$R=$	·740
	$\kappa=\zeta=$	212°·40		$\zeta=$	180°·18		$\zeta=$	99°·59		$\zeta=$	221°·55
S_6	$H=R=$	·012		$H=$	·044		$H=$	·273		$H=$	·762
	$\kappa=\zeta=$	233°·72		$\kappa=$	96°·02		$\kappa=$	119°·12		$\kappa=$	200°·51
			O_1	$R=$	·258	N_2	$R=$	·635	$(2SM)_2$	$R=$	·142
S_8	$H=R=$	·003		$\zeta=$	245°·28		$\zeta=$	345°·93		$\zeta=$	15°·41
	$\kappa=\zeta=$	231°·07		$H=$	·224		$H=$	·654		$H=$	·147
				$\kappa=$	41°·11		$\kappa=$	97°·19		$\kappa=$	36°·45
M_1	$R=$	·018	K_1	$R=$	·505	λ_2	$R=$	...	$2N_2$	$R=$	·184
	$\zeta=$	102°·36		$\zeta=$	210°·62		$\zeta=$	...		$\zeta=$	176°·12
	$H=$	·015		$H=$	·461		$H=$	...		$H=$	·189
	$\kappa=$	66°·19		$\kappa=$	35°·67		$\kappa=$	...		$\kappa=$	59°·67
M_2	$R=$	3·944	K_2	$R=$	·514	ν_2	$R=$	·166	$(M_2N)_4$	$R=$	·319
	$\zeta=$	130°·39		$\zeta=$	315°·12		$\zeta=$	236°·58		$\zeta=$	59°·92
	$H=$	4·064		$H=$	·409		$H=$	·171		$H=$	·339
	$\kappa=$	109°·35		$\kappa=$	144°·71		$\kappa=$	63°·50		$\kappa=$	150°·14
M_3	$R=$	·021	P_1	$R=$	·157	μ_2	$R=$	·378	$(M_2K_1)_3$	$R=$	·221
	$\zeta=$	137°·00		$\zeta=$	246°·08		$\zeta=$	317°·98		$\zeta=$	279°·76
	$H=$	·022		$H=$	·157		$H=$	·401		$H=$	·206
	$\kappa=$	105°·45		$\kappa=$	56°·32		$\kappa=$	275°·90		$\kappa=$	83°·76
M_4	$R=$	·888	J_1	$R=$	·025	R_2	$R=$	...	$(2M_2K_1)_3$	$R=$	·124
	$\zeta=$	202°·50		$\zeta=$	339°·96		$\zeta=$	...		$\zeta=$	277°·27
	$H=$	·942		$H=$	·022		$H=$	...		$H=$	·120
	$\kappa=$	160°·42		$\kappa=$	30°·79		$\kappa=$	...		$\kappa=$	50°·14

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·395	145°·27	·441	12°·97
„ Fortnightly „ . . .	·397	194°·94	·289	42°·23
Luni-Solar „ „ . . .	1·191	20°·81	1·227	41°·85
Solar-Annual „ . . .	2·626	224°·50	2·626	141°·25
„ Semi-Annual „ . . .	·790	79°·48	·790	278°·98

PORT BLAIR, 1911.

Short Period Tides.

A_0 = 4·805 feet.

S_1	H = R =	·014	M_6	R =	·006	Q_1	R =	·015	T_2	R =	·110
	κ = ζ =	109°·46		ζ =	63°·44		ζ =	9°·01		ζ =	304°·74
S_2	H = R =	·965		H =	·007		H =	·013		H =	·110
	κ = ζ =	314°·26		κ =	359°·33		κ =	296°·62		κ =	306°·39
S_4	H = R =	·007	M_8	R =	·001	L_2	R =	·097	$(MS)_4$	R =	·024
	κ = ζ =	198°·44		ζ =	159°·44		ζ =	261°·75		ζ =	195°·88
S_6	H = R =	·002		H =	·001		H =	·077		H =	·025
	κ = ζ =	356°·99		κ =	73°·97		κ =	281°·13		κ =	174°·51
S_8	H = R =	·002	O_1	R =	·185	N_2	R =	·376	$(2SM)_2$	R =	·031
	κ = ζ =	278°·53		ζ =	145°·97		ζ =	162°·86		ζ =	119°·63
				H =	·160		H =	·387		H =	·032
				κ =	301°·46		κ =	273°·61		κ =	141°·00
M_1	R =	·016	K_1	R =	·440	λ_2	R =	...	$2N_2$	R =	·031
	ζ =	343°·96		ζ =	140°·75		ζ =	...		ζ =	12°·41
	H =	·013		H =	·401		H =	...		H =	·032
	κ =	307°·63		κ =	325°·81		κ =	...		κ =	255°·27
M_2	R =	1·974	K_2	R =	·342	ν_2	R =	·029	$(M_2N)_4$	R =	·001
	ζ =	299°·87		ζ =	117°·88		ζ =	34°·78		ζ =	53°·13
	H =	2·034		H =	·272		H =	·030		H =	·001
	κ =	278°·50		κ =	307°·50		κ =	221°·22		κ =	142°·51
M_3	R =	·005	P_1	R =	·138	μ_2	R =	·077	$(M_2K_1)_3$	R =	·019
	ζ =	74°·41		ζ =	153°·68		ζ =	349°·39		ζ =	104°·50
	H =	·005		H =	·138		H =	·082		H =	·017
	κ =	42°·36		κ =	323°·91		κ =	306°·65		κ =	268°·19
M_4	R =	·018	J_1	R =	·036	R_2	R =	...	$(2M_2K_1)_3$	R =	·006
	ζ =	154°·45		ζ =	249°·48		ζ =	...		ζ =	65°·23
	H =	·020		H =	·031		H =	...		H =	·006
	κ =	111°·72		κ =	300°·51		κ =	...		κ =	197°·43

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·058	153°·94	·065	21°·82
„ Fortnightly „ . . .	·080	165°·74	·058	13°·39
Luni-Solar „ „ . . .	·015	292°·99	·015	314°·36
Solar-Annual „ . . .	·267	221°·98	·267	141°·75
„ Semi-Annual „ . . .	·174	353°·33	·174	192°·86

DATA FORWARDED TO ENGLAND.

The following data were supplied to the Director, National Physical Laboratory, Teddington, England :—

(a) Values of the tidal constants for 40 ports for the tide tables for 1915, ready for use for the tide predicting machine.

(b) Actual values during 1910 of every high and low water measured in duplicate from the tidal diagrams at 9 stations, and of tide-pole observations taken during daylight at 3 stations.

(c) Comparisons of the above with predicted values for 1910, the errors being tabulated in such form as to be of use in improving the predictions.

ERRORS IN PREDICTIONS.

The percentage and the amount of errors in the predicted times and heights of high and low water for the year 1911, as given in the tide tables, have been determined by comparison with the actual values obtained from tidal registrations at the 9 stations now working, and from tide-pole readings at two other stations, where regular tidal registrations have been stopped. The errors are tabulated in the five tables herewith appended.

A.

Statement showing the percentage and the amount of the errors in the predicted times of high water at the various Tidal Stations for the year 1911.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden . . .	Auto.	669	45	42	6	4	3
Karāchi . . .	Auto.	704	40	45	8	6	1
Bhāvnagar . . .	T. P.	365	70	30	0	0	0
Bombay { Apollo Bandar .	Auto.	705	40	43	8	6	3
Bombay { Prince's Dock .	Auto.	686	34	43	10	9	4
Madras . . .	Auto.	692	41	43	9	5	2
Kidderpore . . .	Auto.	706	32	40	12	10	6
Akyab . . .	T. P.	365	97	3	0	0	0
Rangoon . . .	Auto.	705	30	34	14	14	8
Moulmein . . .	Auto.	695	24	36	12	16	12
Port Blair . . .	Auto.	705	34	51	10	4	1

B.

Statement showing the percentage and the amount of the errors in the predicted times of low water at the various Tidal Stations for the year 1911.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	669	44	40	8	5	3
Karāchi	Auto.	705	36	45	8	8	3
Bhāvnagar	T. P.	365	69	31	0	0	0
Bombay — Apollo Bandar	Auto.	705	38	45	8	6	3
Bombay — Prince's Dock	Auto.	681	41	41	11	4	3
Madras	Auto.	694	44	44	6	4	2
Kidderpore	Auto.	705	23	35	12	17	13
Akyab	T. P.	363	98	2	0	0	0
Rangoon	Auto.	705	24	31	12	19	14
Moulmein	Auto.	696	13	27	12	18	30
Port Blair	Auto.	705	42	46	7	4	1

C.

Statement showing the percentage and the amount of the errors in the predicted heights of high water at the various Tidal Stations for the year 1911.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at springs, in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	669	6·7	93	7	0	0
Karāchi	Auto.	704	9·3	76	22	2	0
Bhāvnagar	T. P.	365	31·4	68	28	4	0
Bombay — Apollo Bandar	Auto.	705	13·9	77	19	4	0
Bombay — Prince's Dock	Auto.	686	13·9	69	27	4	0
Madras	Auto.	693	3·5	81	19	0	0
Kidderpore	Auto.	706	11·7	41	27	13	19
Akyab	T. P.	365	8·3	85	12	2	1
Rangoon	Auto.	705	16·4	53	25	14	8
Moulmein	Auto.	695	12·7	30	28	20	22
Port Blair	Auto.	705	6·6	93	7	0	0

D.

Statement showing the percentage and the amount of the errors in the predicted heights of low water at the various Tidal Stations for the year 1911.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at springs, in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	669	·7	93	7	0	0
Karāchi	Auto.	705	9·3	81	17	2	0
Bhāvnagar	T. P.	365	31·4	67	30	3	0
Bombay { Apollo Bandar	Auto.	705	13·9	76	21	3	0
Bombay { Prince's Dock	Auto.	681	13·9	73	24	3	0
Madras	Auto.	694	3·5	85	15	0	0
Kidderpore	Auto.	705	11·7	47	26	12	15
Akyab	T. P.	363	8·3	88	11	1	0
Rangoon	Auto.	705	16·4	32	28	21	19
Moulmein	Auto.	696	12·7	37	27	18	18
Port Blair	Auto.	705	6·6	98	2	0	0

E.

Table of average errors in the predicted times and heights of high and low water at the several Tidal Stations for the year 1911.

Stations.	Automatic or tide-pole observations.	Mean range at springs, in feet.	AVERAGE ERRORS.					
			Of time in minutes.		Of height in terms of the range.		Of height in inches.	
			H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
Open coast.								
Aden	Auto.	6·7	8	9	·025	·025	2	2
Karāchi	Auto.	9·3	9	10	·027	·027	3	3
Bhāvnagar	T. P.	31·4	4	5	·011	·011	4	4
Bombay { Apollo Bandar	Auto.	13·9	9	9	·018	·018	3	3
Bombay { Prince's Dock	Auto.	13·9	11	9	·024	·018	4	3
Madras	Auto.	3·5	9	8	·071	·071	3	3
Akyab	T. P.	8·3	0	0	·030	·020	3	2
Port Blair	Auto.	6·6	9	8	·025	·025	2	2
General Mean	...	...	7	7	·029	·027	...	...
Riverain.								
Kidderpore	Auto.	11·7	12	16	·057	·057	8	8
Rangoon	Auto.	16·4	14	16	·025	·041	5	8
Moulmein	Auto.	12·7	15	24	·052	·052	8	8
General Mean	...	...	14	19	·045	·050	...	...

The foregoing statements for the year 1911 may be thus summarised:—

Percentage of time predictions within 15 minutes of actuals.

		High water.	Low water.
		Per cent.	Per cent.
Open coast stations.	6 at which predictions were tested by S. R. tide gauge .	84	84
	2 „ „ „ tide pole . .	100	100
Riverain stations.	3 „ „ „ S. R. tide gauge .	65	51

Percentage of height predictions within 8 inches of actuals.

		High water.	Low water.
		Per cent.	Per cent.
Open coast stations.	6 at which predictions were tested by S. R. tide gauge .	98	99
	2 „ „ „ tide pole . .	97	98
Riverain stations.	3 „ „ „ S. R. tide gauge .	68	66

Percentage of height predictions within one-tenth of mean range at springs.

		High water.	Low water.
		Per cent.	Per cent.
Open coast stations.	6 at which predictions were tested by S. R. tide gauge .	97	98
	2 „ „ „ tide pole . .	100	100
Riverain stations.	3 „ „ „ S. R. tide gauge .	90	90

TIDE TABLES.

The ide tables for the year 1913 have been received from England and distributed to the various officers concerned.

The tide tables for the year 1914 are now being published in England, and the data for the preparation of the tide tables for 1915 were despatched from this office to England in March 1912.

The amount realized on the sale of the tide tables during the year ending September 1912 is Rs. 2,097-4-6.

Comparison of the Predictions at Riverain Stations.

The predictions for the riverain stations for the year 1911 were compared with those for the previous year and the results are briefly summarised as follows :—

The predictions for 1911 at Kidderpore are on the whole better for high and low water times and heights.

At Rangoon and Moulmein, respectively, the predictions for times and heights are about the same for high water, but slightly worse for low water.

The greatest difference between the actual and predicted heights of low water for 1911 was as follows :—

Kidderpore .	3′ 6″	on 25th September 1911, actuals being higher.
Rangoon . .	2′ 9″	on 23rd November 1911, actuals being lower.
Moulmein .	3′ 2″	on 24th July 1911, actuals being higher.

PART V.—LEVELLING.

No. 17 PARTY.

(*Vide* Index Map 10.)

BY LIEUTENANT-COLONEL G. P. LENOX-CONYNGHAM, R.E.

During the past year three Detachments were engaged on levelling operations, their strength being as follows:—

PERSONNEL.

Imperial Officers.

Lieutenant-Colonel G. P. Lenox-Conyngham, R.E., in charge up to March 20th, 1912.
Lieutenant E. B. Cardew, R.E., in charge from June 4th, 1912, to September 11th, 1912.
Captain V. R. Cotter, I.A., in charge from September 12th, 1912.

Provincial Officers.

Mr. Syed Zille Hasnain, in charge from March 21st to June 3rd, 1912.
Mr. D. H. Luxa.
Mr. O. N. Pushong.
Mr. T. F. Kitchen.
Mr. A. M. Talāti.
Mr. O. D. Jackson.
Mr. Jiya Lāl.
Mr. N. Chuckerbutty.

Upper Subordinate Service.

Mr. Karūna Kūmar Das.

Lower Subordinate Service.

10 Recorders.

NO. 1 DETACHMENT.

1st Leveller	Mr. D. H. Luxa.
2nd „	Mr. Jiya Lāl.
Extra „	Mr. K. K. Das.
4 Recorders.	

NO. 2 DETACHMENT.

1st Leveller	Mr. O. N. Pushong.
2nd Levellers	Mr. T. F. Kitchen and Mr. N. Chuckerbutty.
3 Recorders.	

NO. 3 DETACHMENT.

1st Leveller	Mr. A. M. Talāti.
2nd „	Mr. O. D. Jackson.
3 Recorders.	

NO. 1 LEVELLING DETACHMENT.

The following programme of work was allotted to the detachment:—

(1) Check-levelling the line Khushāb-Shahpur.

(2) Continuing the line Khushāb-Shahpur along the high road to Sargodha, thence along the railway line as far as Mithalak railway station, and then along the main road *viâ* Pindi Bhattian, Khāngāh Dogran, Shekhupura and Shahdara to Lahore.

(3) Levelling from Sargodha along the railway line as far as Makhdumpur-Pahoran railway station *viâ* Jhang and Shorkot Road railway stations and thence along the main road to Multān *viâ* Kabīrwala and Kādipur Rau.

(4) Levelling at Delhi in connection with the selection of a site for the new capital.

NO. 2 LEVELLING DETACHMENT.

The following programme of work was allotted to the detachment:—

(1) Levelling from Dumpep *viâ* Karīmganj and Akhaura to Comilla.

(2) Levelling from Karīmganj to Silchār.

(3) Levelling from Akhaura to Brahmanbaria.

NO. 3 LEVELLING DETACHMENT.

The following programme of work was allotted to the detachment:—

(1) Levelling from Minbu to Salin by road, with branch lines along the banks of the Salin Choung.

(2) Levelling from Prome to Rangoon along the Irrawaddy *viâ* Myanaung, Henzāda and Maubin.

THE LINES OF LEVELLING.

The Line Shāhpur-Lahore.—This line was levelled by No. 1 Detachment. It closes the circuit Shāhpur-Lahore-Rāwalpindi-Khushāb-Shāhpur, all the lines of which have been levelled within the last 6 or 7 years. The length of the circuit is 447 miles and the closing error 0·142 of a foot as shown below :—

Lines.		Distance in miles.	Observed difference of elevation in feet.	Seasons.
From	G. T. S. × B. M. At Lahore Railway Station	180·2	+ 983·708	1905-06
To	Standard Bench Mark at Rāwalpindi.			
From	Standard Bench Mark at Rāwalpindi	126·0	− 1,074·659	1910-11
To	G. T. S. O B. M. At Khushāb Railway Station.			
From	G. T. S. O B. M. At Khushāb Railway Station	9·8	− 16·655	1910-11
To	G. T. S. □ B. M. At Shāhpur Dāk Bungalow.			
From	G. T. S. □ B. M. At Shāhpur Dāk Bungalow	130·7	+ 107·748	1911-12
To	G. T. S. × B. M. At Lahore Railway Station.			
		446·7	+ 0·142	...

In deriving the above circuit error the differences in height between Rāwalpindi-Khushāb, Khushāb-Shāhpur and Shāhpur-Lahore have been derived from values shown in the line-forms of these lines, while for that between Lahore and Rāwalpindi the orthometric difference as shown in G. T. S. Volume XIX B, has been used.

The Line Sargodha-Multān.—The line from Sargodha to Multān would have closed two circuits, but before this line closed at Multān the detachment was ordered by wire to proceed immediately to Delhi in order to carry on the levelling that was required there in connection with the selection of a site for the new capital. The closing of the Sargodha-Multān line has therefore been postponed till next season.

Levelling at Delhi.—The levelling at Delhi was carried out in compliance with instructions conveyed in letter No. 1720, dated 8th March 1912, from the surveyor General of India to the Superintendent of the Trigonometrical

Survey. The principal object of this levelling was to fix as many heights as possible over the ground in the vicinity of Delhi, which was being surveyed in connection with the work for the new capital, in order to facilitate the contouring of the ground at vertical intervals of 5 feet. No. 1 Detachment was strengthened by the addition of two more levellers, 4 plane-tablers, 1 recorder and 20 menials as shown in the margin. The work was carried out under the personal supervision and direction of Mr. Syed Zille Hasnain, Officer in charge No. 17 Party, but the actual charge of the detachment remained in the hands of Mr. D. H. Luxa.

EXTRA PERSONNEL AT DELHI.

Levellers.

Mr. Karūna Kūmar Das.
Munshi Nabidad Khan.

Plane-tablers.

Mr. Ram Singh, Rai Sahib.
Mr. Jugal Bihari Lal.
Babu Kunj Behari Lal.
Soldier Surveyor Chanan Khan.
1 recorder and 20 menials.

Mr. T. R. J. Ward, C.I.E., M.V.O., the Superintending Engineer, on special duty at Delhi, and Lieutenant A. A. Chase, R.E., Officer in charge of the Delhi Survey Detachment, were consulted regarding the scope of the levelling required and the best method of carrying it out. The following was the plan of operations adopted:—

(*i*) As the contoured maps of the country around Delhi were required very urgently and within the shortest possible time, double levelling was abandoned and single levelling resorted to.

(*ii*) Main circuits of levels were run over the principal roads and cart-tracks dividing the area into suitable blocks, fixing permanent bench-marks at distances of about $\frac{1}{2}$ a mile apart.

(*iii*) After closing the main circuits, cross lines of levels were run in such a manner that the whole area was covered with spirit-levelled heights at about 500 feet apart, the positions of these heights whether on permanent bench-marks or pegs were plotted on the four-inch map by the plane-tabler attached to each leveller, as soon as the heights of the points had been determined.

In conformity with the above plan, levelling was commenced over the ground immediately to the south and south-west of Delhi, as this area was considered most important and the contoured maps of it were required first. Subsequently levelling was extended in all directions and was carried out wherever spirit-levelled heights were required by the Delhi Survey Detachment for purposes of contouring; or by the Superintending Engineer, for the special requirements of the new capital.

The total outturn at Delhi amounted to 233 miles of single levelling in the course of which the heights of 90 permanent bench-marks, 33 canal bench-marks and 1,852 temporary points were determined. In the last group were included 240 points on the tops or upper surfaces of water gauges, mile and furlong stones, bridges, wells and floors or pavements; 12 high flood level marks; 31 water level pegs along the west bank of the Jumna River, extending over a length of 12 miles; and 1,570 pegs.

The work at Delhi was commenced on the 29th March and completed on the 14th May 1912.

The levelling at Delhi has served a very useful purpose in linking together the heights of the 3 canal systems, *viz.* :— (*i*) Western Jumna Canal, (*ii*) Eastern Jumna Canal and (*iii*) the Agra Canal. A number of bench-marks of all the three systems were connected by levelling and the mean

differences between the Great Trigonometrical Survey and the Canal heights were found as follows :—

Western Jumna Canal	2·13 feet.
Eastern Jumna Canal	1·45 „
Ágra Canal	1·27 „

The Canal heights in every case were higher than the G. T. Survey heights.

Although the levelling done at Delhi was single levelling, yet the principal precautions ordinarily observed in levelling of precision were adhered to. The departures from the established practice were that the staves were not guyed, and that the same staff was not always placed on every point connected ; before starting work, however, care was taken that every leveller used a pair of staves with practically accordant zeros. The work was divided into a series of circuits and sub-circuits and was so arranged that each section commenced from and closed on a point whose height had been previously determined, so that it was impossible for any gross error to creep into the work without being detected.

Traces showing all the levelling done by the detachment at Delhi and its vicinity were prepared and supplied to the Superintending Engineer before the detachment returned to recess quarters. On these traces, the positions of all points, both permanent and temporary, whose heights had been determined were shown with their reference numbers and approximate heights.

On return to recess quarters the corrections for unit length of staves and for the dispersion of the closing errors of circuits and sub-circuits were determined. The closing error of the main circuit which enclosed the whole of the levelling done at Delhi amounted to 0·114 of a foot, the length of circuit being 62·3 miles. A schedule containing a list of all points connected at Delhi with the corrected heights of all bench-marks, water level pegs, high flood level marks, borings and gauges were forwarded to the Superintending Engineer on special duty at Delhi.

The Line Dumpep-Comilla—Was carried on by No. 2 Detachment and was an entirely new line.

The Line Karīmganj-Silchār—Levelled by No. 2 Detachment is a new line.

The Line Akhaura-Brahmanbaria—Is a new line and was levelled by No. 2 Detachment.

The levelling circuit in which this line is included will be closed next field season if possible.

The Line Minbu-Salin—Was levelled by No. 3 Detachment and is a new line. This was carried along the road between the two places with branch lines of about 10 miles length along the Salin-Choung.

The Line Prome-Rangoon—This line is new and was carried along the Irrawaddy embankment *viâ* Myanaung, Henzāda and Maubin. The work was done by No. 3 Detachment. It was at first proposed to carry the line along the railway embankment and bench-marks were built for the purpose and are still in existence. The question of whether they shall be destroyed as misleading is under consideration. During the next field season it is expected that the levelling circuit Rangoon-Toungoo-Meiktila-Prome-Henzāda-Rangoon will be completed.

Destruction of Bench-marks.—**During the past year out of 86 old bench marks inspected, 10 were found destroyed and 1 could not be found.**

N 2

Zinc plate Bench-marks.—A new type of bench-mark was experimentally made use of. This consisted of a zinc plate with the letters $\overset{\text{G.T.S.}}{\underset{\text{B.M.}}{\text{O}}}$ inscribed on it, firmly nailed to a flat surface cut on the root of a tree. The results of our future check-levelling will prove whether this type of bench-mark is sufficiently reliable to be resorted to when no suitable permanent structures are available.

Aluminium Staves.—A new pattern of aluminium staff has been designed, and will be experimentally tried during the next field season.

Outturn of Detachments.—The combined tabular statements of the 3 detachments show the outturn of the party. The single levelling carried out in Delhi has been included. The tabular statements of detachments have also been shown separately under Table I.

Old G. T. Survey Bench-marks.—Table II shows the discrepancies between the new and old values of height of bench-marks which are common to the lines of the new and previous operations.

The noticeable discrepancies found in the check-levelling of Nos. 1 and 2 Detachments are not very important except in one case and are as follows:—

(*a*) The bench-mark on masonry block on milestone 6 from Shahpur on the line between Khushāb and Shahpur was found to have sunk 0·04 of a foot. This was attributed to its being situated very near the river bank.

(*b*) The bench-mark on Badāmi Bāgh railway station was found to have sunk 0·05 of a foot. The surface of the stone appeared much worn, which would account for a portion of the subsidence.

(*c*) The new work between Lahore and Shahdara has proved that the embedded bench-mark, No. $\frac{60}{44\text{I}}$, at Lahore railway station has sunk by 0·09 of a foot. The height of this bench-mark was first determined by the original levelling in 1866-67. The bench-mark was then made use of as a starting point for the new line to Peshawar carried out in 1905-06. In the same year a standard bench-mark was connected at Lahore Cantonment, but certain bench-marks in its neighbourhood were used for check-levelling, so the standard bench-mark was not connected with bench-mark No. $\frac{60}{44\text{I}}$ on Lahore railway station.

In season 1909-10, discrepancies in levelling between bench-mark No. $\frac{60}{44\text{I}}$ and Lahore Cantonment led us to believe that bench-mark No. $\frac{60}{44\text{I}}$ at Lahore railway station had sunk by 0·09 of a foot, between seasons 1866-67 and 1905-06. This evidence however was not considered conclusive. In view of the additional evidence obtained during this season we may now take the subsidence as finally proved.

As regards the check-levelling of No. 3 Detachment in Burma, the results were not so satisfactory. A reference to Table II will show that 6 bench-marks have sunk by more than ·05 of a foot and that in two of these the subsidence is over ·10 of a foot.

Among these six bench-marks, two are on the Dala Pagōda. The whole of this building appears to have sunk appreciably. The Shwé Dagōn Pagōda showed no signs of subsidence and the bench-mark on it may be regarded as an extremely reliable one.

It is satisfactory to note that of the 2 standard bench-marks in Rangoon, the one in the Cantonment gardens has remained unaltered in height, and the

one at the flag staff appears to have sunk by a very small quantity only, *viz.*:—·019 of a foot.

In arriving at the above conclusion, it should be noted that the subsidences are noted relative to Graham Smith's Bench-mark, which is yearly levelled to by No. 16 Party, in connection with tidal operations and has invariably been found extremely reliable.

Standard Bench-marks.—A statement showing the standard bench-marks constructed and connected, is appended (Table VII).

TABLE I.

Tabular Statement of Outturn of work, season 1911-12.

No. of Detachment.	Section.	Number of Miles of Levelling.									Total number of feet.		Number of stations at which instrument was set up.	Number of Bench-Marks Connected.																					Remarks.
		Line.			Extra and Auxiliary.			Total.			Rise.	Fall.		Primary.					Secondary.																
																			Old.		New.														
		Mls.	chs.	lks.	Mls.	chs.	lks.	Mls.	chs.	lks.				Rock-cut protected.	Standard.	Principal station of Triangulation.	Interred.	Engraved.	Embedded.	Inscribed.	Embedded.	Inscribed.	Rock-cut.	Irrigation.	Railway.	P. W. D.	Zinc-plates.	G.T.S. Traverse mark-stones.	Secondary station of Trg.	H.F.L. Marks.	Water level pegs.	Temporary inscribed marks.	Pegs.	Metal bolts.	
No. 1 Detachment	Grand Totals of double and single levelling.	307	70	30	317	15	10	625	05	40	5979·729	5427·214	7707	1	1*	4	...	...	12	37	34	330	30	93	16	1	16	3†	1	12	31	240	1570	...	* Old. † Traverse mark-stones laid down by Triangulation Party.
No. 2 "	Grand Totals	283	16	92	44	18	60	327	35	52	3217·383	9101·652	4086	‡4+2§	3	11	2	6	...	1	21	131	27+1§	...	10	31	37	...	...	...	...	...	...	7	‡ 1 new B.M. in the Line Gauhati to Dumper. § Old bench-marks.
No. 3 "	Grand Totals	342	22	86	51	07	14	393	30	00	3746·678	3882·497	5287	...	6	1	...	...	2	20	39	140	4	...	...	147	...	...	...	...	...	...	...	...	
	Grand Totals	933	30	08	412	40	84	1,345	70	92	12943·790	18411·363	17980	7	10	16	2	6	14	58	94	618	62	93	26	179	53	3	1	12	31	240	1570	7	

TABLE I (*contd.*)—No. 1 LEVELLING DETACHMENT.

Tabular Statement of Outturn of work, season 1911-12.

Section.	Month.	Number of miles of double levelling. Line. Mls. chs. lks.	Extra and Auxiliary. Mls. chs. lks.	Total. Mls. chs. lks.	Total number of feet. Rise.	Fall.	Number of stations at which instrument was set up.	Number of bench-marks connected. Primary. Rock-cut protected.	Standard.	Principal station of Triangulation.	Secondary. Old. Embedded.	Old. Inscribed.	Embedded.	Inscribed.	Rock-cut.	Irrigation.	Railway.	P. W. D.	Zinc-plates.	G. T. S. Traverse mark-stones.	Secondary station of Triangulation.	H. F. L. marks.	Water level pegs.	Temporary inscribed mark.	Pegs.	Remarks.
Check-levelling between Khushab-Shahpur.	November 1911	...	9 23 98	9 23 98	71·588	78·375	159	...	...	...	3	8	...	...	...	...	...	...	...	...	...	...	...	...	...	
	TOTALS	...	9 23 98	9 23 98	71·588	78·375	159	...	...	...	3	8	...	...	...	...	...	...	...	...	...	...	...	...	...	
Shahpur to Lahore	November 1911	36 55 98	1 71 00	38 46 98	210·243	180·943	452	...	...	...	...	...	4	22	...	6	6	...	...	...	...	...	...	...	...	
	December 1911	73 03 96	15 42 66	88 46 62	677·993	388·213	970	...	...	4	...	...	6	55	1	13	...	...	7	...	..	...	...	...	...	
	January 1912	24 34 78	0 43 62	24 78 40	230·394	207·518	255	...	...	...	1	3	2	8	...	14	4	...	4	...	...	...	...	...	...	
	TOTALS	134 14 72	17 78 28	152 12 00	1118·630	776·674	1,677	..	...	4	1	3	12	85	1	33	10	...	11	...	...	...	...	...	...	
Check-levelling at Lahore and between Lahore, etc.	January 1912	...	11 78 54	11 78 54	46·338	45·921	156	...	1*	...	6	19	...	...	...	...	...	...	...	...	...	...	...		...	* Old.
	TOTALS	...	11 78 54	11 78 54	46·338	45·921	156	...	1*	...	6	19	...	...	...	...	...	...	...	...	...	...	...	...	...	
Sargodha to Multan including branch lines to Sidhrai canal and Channu.	January 1912	44 13 66	6 47 78	51 08 44	169·997	203·785	563	1	...	...	2	2	2	48	7	...	1	...	...	...	...		...	...	...	† Traverse mark-stones laid down by triangulation party.
	February 1912	83 26 96	7 17 36	90 44 32	343·505	419·683	1,058	...	...	...	...	...	14	86	...	4	1	...	...	2	...		...	...	...	
	March 1912	46 14 96	30 42 10	76 57 06	281·999	298·067	916	...	...	...	...	...	6	48	...	23	4	1	4	1†	...	..	...	...	...	
	TOTALS	173 55 58	44 54 24	218 29 82	795·501	921·535	2,537	1	...	...	2	2	22	182	7	27	6	1	4	3†	...	...		...	...	
Sum totals of double levelling.		307 70 30	83 74 04	391 64 34	2032·057	1822·505	4,529	1	1*	4	12	32	34	267	8	60	16	1	15	3†	...	...	...	...	...	
		NUMBER	OF MILES LEVELLING.	OF SINGLE																						
Single levelling at Delhi in connection with the new capital.	April 1912 May 1912	...	233 21 06	233 21 06	3947·672	3604·709	3,178	...	...	...	...	5	...	63	22	33	...	...	1	...	1	12	31	240	1570	
Sum totals of single levelling.		...	233 21 06	233 21 06	3947·672	3604·709	3,178	...	...	...	...	5	...	63	22	33	...	...	1	...	1	12	31	240	1570	
Grand totals of double and single levelling.		307 70 30	317 15 10	625 05 40	5979·729	5427·214	7,707	1	1*	4	12	37	34	330	30	93	16	1	16	3†	1	12	31	240	1570	

TABLE I (*contd.*)—No. 2 LEVELLING DETACHMENT.

Tabular Statement of Outturn of work, season 1911-12.

Section.	Months.	Number of miles of double-levelling.			Total number of feet.		Number of stations at which instrument was set up.	Number of bench-marks connected.													Remarks.
								Primary.					Secondary.								
		Line.	Extra and Auxiliary.	Total.	Rise.	Fall.		Rock-cut protected.	Interred.	Engraved.	Standard.	Principal station of Triangulation.	Embedded.	Inscribed.	P. W. D.	Secondary stations of Triangulation.	Rock-cut.	Zinc-plates.	Metal bolts.	Railway.	
		Mls.chs.lks.	Mls.chs.lks.	Mls.chs.lks.																	
Dumpep to Comilla	December 1911	19 70 46	2 10 14*	22 00 60	414·993	3519·741	727*	† ‡ 3+2	...	2	...	1	...	1‡	...	...	22+1‡	...	...	...	*Includes check-levelling at Dumpep. †One new B. M. in Line Gauhati to Dumpep. ‡ Old bench-marks.
	January 1912	59 43 72	10 45 93	70 09 65	663·835	3604·706	1236	1	1	2	1	3	3	34	22	...	5	8	...	...	
	February 1912	34 59 82	00 08 10	34 67 92	295·070	304·783	413	...	..	1	...	...	4	8	4	...	...	8	2	6	
	March 1912	71 78 44	16 62 42	88 60 86	832·644	843·392	1124	...	...	...	...	2	7	23	...	...	.	14	...	4	
	April 1912	48 41 98	9 24 52	57 66 50	354·841	353·977	752	...	...	...	1	2	5	31	1	...	...	3	1	...	
	TOTALS	234 54 42	38 71 11	273 45 53	2561·383	8626·599	4252	† ‡ 4+2	1	5	2	8	19	96+1‡	27	...	27+1‡	33	3	10	
Karimganj to Silchar	February 1912	35 29 18	5 14 59	40 43 77	579·756	406·275	610	...	1	1	1	3	1	24	4	...	..	3	4	...	
	TOTALS	35 29 18	5 14 59	40 43 77	579·756	406·275	610	...	1	1	1	3	1	24	4	...	...	3	4	...	
Akhaura to Brahmanbaria.	April 1912	13 13 32	00 12 90	13 26 22	76·244	68·778	124	...	...	...	...	...	1	11	...	...	...	1	...	...	
	TOTALS	13 13 32	00 12 90	13 26 22	76·244	68·778	124	...	...	...	...	...	1	11	...	...	...	1	...	...	
	GRAND TOTALS	283 16 92	44 18 60	327 35 52	3217·383	9101·652	4,986	† ‡ 4+2	2	6	3	11	21	131+1‡	31	...	27+1‡	37	7	10	

NOTE.—Totals in auxiliary lines to G. T. H. Stations of Rises 2851·982 and Falls 992·917.

TABLE I (*concld.*)—No. 3 LEVELLING DETACHMENT.

Tabular Statement of Outturn of work, season 1911-12.

Section.	Month.	Number of miles of double levelling. Line. Mls. chs. lks.	Extra and Auxiliary. Mls. chs. lks.	Total. Mls. chs. lks.	Total number of feet. Rise.	Fall.	Number of stations at which instrument was set up.	Number of bench-marks connected. Primary. Standard.	Principal station of Triangulation.	Secondary. Old. Embedded.	Old. Inscribed.	New. Embedded.	New. Inscribed.	New. Rock-cut.	New. P. W. D.	Remarks.
Minbu to Paugma	December 1911	53 06 14	13 17 84	66 23 98	792·342	747·204	867	1	...	1	1	6	48	2*	...	* One old.
Paugma to Salin	December 1911	3 42 52	0 12 56	3 40 38	52·268	65·780	55	...	...	...	...	...	2	...	...	
	January 1912	18 14 20	4 44 62	22 58 82	252·231	310·318	322	...	...	...	...	...	22	...	...	
	TOTALS	74 62 86	17 75 02	92 57 88	1096·841	1123·302	1,244	1	...	1	1	6	72	2	...	
Prome to Rangoon	January 1912	36 58 74	8 13 74	44 72 48	717·390	747·047	695	1	1	...	...	4	16	2	1	
	February 1912	85 38 00	3 11 54	88 49 54	975·969	1028·835	1,211	2	...	...	...	10	29	...	47	
	March 1912	72 28 92	3 46 50	75 75 42	550·177	586·578	1,008	...	...	...	...	8	16	...	57	
	April 1912	65 22 92	14 62 24	80 05 16	351·300	346·788	968	...	...	...	3	11	16	...	41	
	May 1912	7 51 42	3 38 10	11 58 52	55·001	50·002	161	2*	...	1	16	...	...	...	1	*Old.
	TOTALS	267 40 00	33 12 12	300 52 12	2649·837	2759·195	4,043	5	1	1	19	33	77	2	147	
	GRAND TOTALS	342 22 86	51 07 14	393 30 00	3746·678	3882·497	5,287	6	1	2	20	39	149	4	147	

TABLE II.

Tabular statement of difference of height between original and check-levelling.

Bench-marks of the original levelling that were connected for check-levelling. Description.	Distance from starting bench-mark.	Observed height above (+) or below (−) starting bench-mark as determined by Original levelling.	Check-levelling, 1911-12.	Difference in height (Check-levelling − Original). The sign + denotes that the height was greater and the sign − less in 1911-12 than when originally levelled.	Remarks.
	Miles.	Feet.	Feet.	Feet.	
Check-levelling between Khushāb and Shāhpur, part of line 55E (Khushāb-Lahore), 1911-12.					
G. T. S. □ B. M. At Khushāb Dāk Bungalow	0·0	0·000	0·000	0·000	
G. T. S. O B. M. In the Central passage, Khushāb Ry. Station.	0·3	+9·866	+9·867	+0·001	
G. T. S. O B. M. On coping of platform, Khushāb Ry. Station	0·3	+9·724	+9·727	+0·003	
G. T. S. O B. M. At Kabulee gate, Khushāb .	0·2	+4·826	+4·825	−0·001	
G. T. S. O B. M. At Lahoree gate, ditto .	0·8	−3·776	−3·789	−0·013	
G. T. S. □ B. M. On masonry block at M. S. 6 from Shāhpur.	2·9	−12·990	−13·029	−0·039	Probably sunk site too close to river bank.
G. T. S. O B. M. At Lahoree gate, Shāhpur City.	6·1	−5·297	−5·288	+0·009	
G. T. S. O B. M. At Munsif's Court, Shāhpur Civil Station.	9·2	−4·220	−4·203	+0·017	
G. T. S. O B. M. At District Board's Office, Shāhpur.	8·7	−3·961	−3·946	+0·015	
G. T. S. O B. M. At Church, Shāhpur Civil Station.	8·6	−3·354	−3·337	+0·017	
G. T. S. O B. M. At Katchéri, Shāhpur Civil Station.	8·8	−2·000	−1·978	+0·022	
G. T. S. □ B. M. At Shāhpur Dāk Bungalow	8·9	−6·931	−6·926	+0·005	
Check-levelling between Lahore and Shahdara at Lahore and between Lahore and Lahore Cantonment, part of main line No. 56, 1905-06.					
Check-levelling between Lahore and Shahdara.					
G. T. S. × B. M. ~~At~~ Lahore Ry. Station .	0·0	0·000	0·000	0·000	
G. T. S. O B. M. At coping of platform at Badāmi Bāgh Railway Station.	1·7	−8·375	−8·426	−0·051	Surface of stone very much worn.
G. T. S. O B. M. At S. abutment of Rāvi bridge.	2·9	+0·844	+0·866	+0·022	
G. T. S. O B. M. At N. abutment of Rāvi bridge.	3·3	+0·824	+0·832	+0·008	

TABLE II—*contd.*

Tabular statement of difference of height between original and check-levelling.

Bench-marks of the original levelling that were connected for check-levelling. Description.	Distance from starting bench-mark.	OBSERVED HEIGHT ABOVE (+) OR BELOW (−) STARTING BENCH-MARK AS DETERMINED BY Original levelling.	Check-levelling, 1911-12.	Difference in height (Check levelling—Original). The sign + denotes that the height was greater and the sign − less in 1911-12 than when originally levelled.	REMARKS.
	Miles.	Feet.	Feet.	Feet	
G. T. S. □ B. M. At (old) Shahdara Railway Station.	5·0	−13·796	−13·778	+0·018	
G. T. S. O B. M. At bridge No. 10, 3 chs: S. E. of T. P. No. $\frac{341}{3}$	5·3	−12·126	−12·128	−0·002	
G. T. S. O B. M. At Drain No. 3, between T. P. Nos. $\frac{341}{12}$ and $\frac{341}{13}$	5·7	−14·167	−14·139	+0·028	
G. T. S. O B. M. At bridge near T. P. No. $\frac{342}{20}$	7·1	−8·974	−8·960	+0·014	
Check-levelling at Lahore.					
G. T. S. O B. M. At Lahore Ry. Station	0·0	0·000	0·000	0·000	
G. T. S. O B. M. At W. end of No. 2 platform, Lahore Ry. Station.	0·0	+2·612	+2·619	+0·007	
G. T. S. O B. M. At centre of No. 2 platform, Lahore Ry. Station.	0·1	+2·570	+2·567	−0·003	
G. T. S. O B. M. At E. end of No 2 platform, Lahore Ry. Station.	0·1	+2·583	+2·567	−0·016	
G. T. S. □ B. M. Embedded at N.-W. Railway Institute, Lahore.	0·4	−1·734	−1·737	−0·003	
G. T. S. B. M. ▲ Embedded at N.-W. Railway Central Offices, Lahore.	1·0	−9·528	−9·539	−0·011	
▲ On steps at N.-W. Railway Central Offices, Lahore.	1·0	−5·636	−5·644	−0·008	
G. T. S. B. M. O On sill under N. porch of the Cathedral, Lahore.	2·4	−2·854	−2·844	+0·010	
G. T. S. B. M. O On sill under W. porch of the Cathedral, Lahore.	2·4	−2·915	−2·907	+0·008	
G. T. S. O B. M. At Chief Court, Lahore	2·7	− 7·438	− 7·427	+ 0·011	
G. T. S. O B. M. At S. side of General Post Office, Lahore.	2·8	−15·625	−15·627	− 0·002	
G. T. S. O B. M. At E. side of General Post Office, Lahore.	2·8	−15·691	−15·710	− 0·010	

TABLE II—*contd.*

Tabular statement of difference of height between original and check-levelling.

Bench-marks of the original levelling that were connected for check-levelling. Description.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by Original levelling.	Observed height above (+) or below (—) starting bench-mark as determined by Check-levelling, 1911-12.	Difference in height (Check-levelling—Original). The sign + denotes that the height was greater and the sign — less in 1911-12 than when originally levelled.	Remarks.
	Miles.	Feet.	Feet.	Feet.	
G. T. S. O B. M. At S. side of University Hall, Lahore.	3·2	—17·851	—17·866	—0·015	
G. T. S. O B. M. At N. side of Museum, Lahore.	3·3	—15·842	—15·844	—0·002	
Check-levelling between Lahore and Lahore Cantonment.					
G. T. S. × B. M. Embedded at Lahore Railway Station.	0·0	0·000	0·000	0·000	
G. T. S. □ B. M. Embedded at North-Western Railway General Stores, Lahore.	0·7	—2·602	—2·598	+0·004	
G. T. S. □ B. M. Embedded at Shalamar Road over bridge.	1·0	—2·144	—2·156	—0·012	
G. T. S. O B. M. At Drain near Running Shed and Engine Reversing Table.	1·2	—9·742	—9·731	+0·011	
G. T. S. O B. M. At bridge No. 213, ¼ mile south-east of Shalamar Road over bridge. *	1·3	+0·553	+0·639	+0·086	* Connected by No. 3 Levelling Detachment on Line Lahore-Dharmkot, season 1909-10.
G. T. S. O B. M. On coping of platform, Lahore Cantonment, East Railway Station. *	3·0	+7·510	+7·606	+0·090	
G. T. S. Standard Bench Mark 1904. At Lahore Cantonment.	5·7	+3·050	+3·134	+0·084	
+ On step under steeple tower Church of England, Lahore Cantonment.	5·8	+1·614	+1·700	+0·086	On first examination these 6 bench-marks from the check-levelling appeared to have altered their values, but this is really not the case, as the embedded B. M. at the Lahore Railway Station has been proved to have sunk by 0·09 of a foot.
+ On sill of doorway under steeple tower Church of England, Lahore Cantonment.	5·8	+2·853	+2·939	+0·086	
G. T. S. + B. M. Embedded at Church of England, Lahore Cantonment.	5·9	—0·334	—0·249	+0·085	
Check-levelling at Minbu : Line 88 (Thazi to Magwe).					
O G. T. S. B. M. On rock near D. C.'s Bungalow, Minbu.	0·0	0·0	0·0	0·0	In good condition.
G. T. S. □ B. A. D. 1903 M. Embedded at P. W. D. Inspection Bungalow, Minbu.	0·3	—74·531	—74·488	+0·043	Ditto
G. T. S. O B. M. At Culvert, 4 chs. N. W. of Taukshabin Inspection Bungalow.	2·1	—92·466	—92·547	—0·081	The brick on which the circle was cut was found chipped at one corner.

TABLE II—*contd.*

Tabular statement of difference of height between original and check-levelling.

Bench-marks of the original levelling that were connected for check-levelling. Description.	Distance from starting bench-mark.	Observed height above (+) or below (−) starting bench-mark determined by Original levelling.	Check-levelling.	Difference in height (Check-levelling—Original). The sign + denotes that the height was greater and the sign — less in 1911-12 than it was when originally levelled.	Remarks.
	Miles.	Feet.	Feet.	Feet.	
Check-levelling at Rangoon: Main Line 87 (Elephant Point to Myitkyina).					
Graham Smith's Bench-mark, Rangoon.	0·0	0·0	0·0	0·0	In good condition.
G. T. S. O B. M. 1 at Dala	11·3	−0·158	−0·243	−0·085	The pagōda appears to have sunk.
G. T. S. O B. M. 2 at do.	11·3	+0·158	+0·034	−0·124	
B. ↑ M. of Mile O of Rangoon-Twante Road.	11·1	−3·500	−3·562	−0·062	The mile post has most probably sunk.
G. T. S. O B. M. At Level-crossing No. 1 of wharf siding.	3·5	+10·853	+10·843	−0·010	In good condition.
B. ⊕ M. On W. side of Lower Kemmendine Road.	3·3	+8·826	+8·784	−0·042	Mark intact, but the plaster had cracked off in places, the pillar was repaired.
G. T. S. O B. M. At Bridge near Level Crossing No. 3.	2·8	+2·201	+2·094	−0·107	The mark appears to be intact, but the surrounding plaster had all fallen away. It was repaired.
↑ B. M. 168. About 1 chain N. of Supply and Transport Corps wharf, Rangoon.	1·3	+1·136	+1·083	−0·053	In good condition.
O B. ψ M. About 1 chain N. of Supply and Transport Corps wharf, Rangoon.	1·3	+1·153	+1·095	−0·058	Ditto.
↑ B. M. 169. Near gateway of Crisp Street jetty, Rangoon.	1·2	+0·808	+0·762	−0·046	Ditto.
G. T. S. C O B. M. At rubbishbin, near wharf godown No. 16.	1·1	+0·920	+0·900	−0·020	Ditto.
G. T. S. O B. M. At General Post Office, Rangoon.	0·6	+0·576	+0·569	−0·007	Ditto.
Standard Bench-Mark for Rangoon } At Flag-Staff, Rangoon.	0·4	+3·633	+3·614	−0·019	Ditto.
B. O. M. At N. W. corner of Brooking Street, wharf godown.	0·1	+1·107	+1·099	−0·008	Ditto.
B. O. M. At S. W. corner of Brooking Street, wharf godown.	0·1	+1·172	+1·158	−0·014	Ditto.
↑ B. M. 31. At Municipal Office, Rangoon	0·8	+1·995	+1·967	−0·028	Ditto.
G. T. S. O B. M. At Sūlē Pagōda, Rangoon .	0·8	+3·472	+3·458	−0·014	Ditto.

TABLE II—*concld.*

Tabular statement of difference of height between original and check-levelling.

Bench-marks of the original levelling that were connected for Check-levelling. Description.	Distance from starting bench-mark.	OBSERVED HEIGHT ABOVE (+) OR BELOW (—) STARTING BENCH-MARK DETERMINED BY Original levelling.	Check-levelling.	Difference in height (Check levelling — Original). The sign + denotes that the height was greater and the sign — less in 1911-12 than it was when originally levelled.	REMARKS.
	Miles.	Feet.	Feet.	Feet.	
G. T. S. □ At Railway Audit Offices, Rangoon.	1·3	+13·879	+13·863	—0·016	Half the block has been broken off probably in digging for garden. It was found in same condition in 1909-10.
B. M. 66. South of Entrance gate to Presbyterian Church.	1·4	+25·369	+25·357	—0·012	In good condition.
B. M. 108. At Shwé Dagōn Pagōda, Rangoon.	2·8	+92·603	+92·610	+0·007	Ditto.
Standard Bench-Mark at Cantonment gardens.	3·0	+93·003	+93·003	0·000	Ditto.

Check-levelling at Dumpep.

G. T. S. O B. M. At rock near Dumpep D. B.	0·0	0·000	0·000	...	
G. T. S. O. B. M. At do.	0·13	—11·415	—11·410	+0·005	
G. T. S. O B. M. At rock between M. S. Nos. 17 and 18 from Shillong.	0·27	+9·156	+9·155	—0·001	

TABLE III.

List of Great Trigonometrical Survey stations connected by spirit levelling in season 1911-12.

No. of Detachment.	Name of station.	Height in feet above mean sea-level. By spirit levelling.	By Triangulation.	Difference in height from Triangulation in feet.	Remarks.
No. 1 Levelling Detachment.	Hūjan Tower Station	646·232	655	+ 8·768	Ground floor mark-stone.
	Fatti " "	667·360	676	+ 8·640	Ditto ditto.
	Sāngla Hill Station	824·531	837	+12·469	⊙ On bed rock.
	Asrūr Tower Station	729·170	737	+ 7·830	Mark-stone about 3 feet below top surface of pillar.

Eastern Frontier Series Section 23° to 26°.

No. of Detachment.	Name of station.	By spirit levelling.	By Triangulation.	Difference	Remarks.
					* Approximate.
No. 2 Levelling Detachment.	Rangsanobo H. S.	4457·026	4458·9*	+ 1·874	Upper mark-stone.
	Abangi Tila "	257·800	257	— 0·800	Ditto ditto.
	Kailas Tila "	208·687	211	+ 2·313	4 feet above foundation.
	Mama Bhagna Tila T. S.	82·190	81	— 1·190	Lowest mark-stone.
	Lauraga Tila H. S.	193·200	194	+ 0·800	Ditto ditto.
	Churamani H. S.	282·892	284·5	+ 1·608	Middle mark-stone.
	Lambusāra "	183·088	185·25	+ 2·162	Lowest mark-stone.
	Barjatua "	156·039	156·5	+ 0·461	Ditto ditto.
	Dali Tila "	158·062	157	— 1·062	Upper mark-stone.

Cachār Branch of the Eastern Frontier Series.

No. of Detachment.	Name of station.	By spirit levelling.	By Triangulation.	Difference	Remarks.
No. 2, Levelling Detachment.	Murphuta Tila H. S.	572·669	572·67	— 0·001	Lowest mark-stone
	Salama Tila	221·233	220	— 1·233	Ditto ditto.
No. 3 Levelling Detachment.	Myinmyindaung H. S.	574·547	576	+ 1·453	Upper mark-stone.

TABLE IV.— No. 1 LEVELLING DETACHMENT.

Result of comparison of staves, season 1911-12—Single faces.

The results were obtained by comparing the staves with portable 10-foot standard steel bars during the field season. The correction for difference in unit of pair of staves has been applied to the observed heights in order to obtain the absolute heights :

Place and date of comparison.	Number of staff.				Remarks.
	05.	02.	01.	03.	
	Feet.	Feet.	Feet.	Feet.	
Khushāb, 10th November 1911.	+0·00252	+0·00119	−0·00228	−0·00241	Light scattered clouds, cool breeze.
Shāhpur, 18th November 1911.	+0·00126	+0·00102	−0·00227	−0·00310	Rain once since last comparison, light scattered clouds, cool breeze.
Sargodha, 26th November 1911.	−0·00059	−0·00009	−0·00449	−0·00590	Clear and dry.
Laksin, 5th December 1911	+0·00012	+0·00018	−0·00398	−0·00554	Light scattered clouds and cool breeze.
Pindi Bhattian, 14th December 1911.	+0·00047	+0·00003	−0·00385	−0·00550	Rain once since last comparison, cloudy.
Khāngāh Dogran, 23rd December 1911.	−0·00021	−0·00044	−0·00516	−0·00704	Sandstorm once, light scattered clouds, cool and dry.
Shekhupūra, 31st December 1911.	−0·00067	−0·00023	−0·00454	−0·00653	Mornings cloudy, afternoons clear, cool and dry.
Shahdara, 8th January 1912	−0·00048	−0·00052	−0·00471	−0·00603	Drizzled twice, foggy twice, cloudy.
Sargodha, 15th January 1912	+0·00079	+0·00031	−0·00389	−0·00491	Rain once, mornings misty and cloudy.
Silanwali, 24th January 1912	+0·00060	+0·00005	−0·00382	−0·00447	Rain, light scattered clouds, cool.
Shalyewāna, 30th January 1912.	−0·00005	−0·00035	−0·00414	−0·00556	Drizzled twice, cloudy mornings, weather very variable.
Jhang Maghiana, 7th February 1912.	−0·00020	−0·00008	−0·00404	−0·00551	Clear and cool mornings, weather very variable.
Rustam Sargana, 14th February 1912.	−0·00018	+0·00003	−0·00485	−0·00592	Drizzled once, next day cloudy, otherwise clear and cool.
Darkhana, 22nd February 1912.	+0·00000	+0·00022	−0·00491	−0·00581	Cloudy, once drizzled, once otherwise dust, haze and cool breeze.
Abdul Hakim, 1st March 1912.	−0·00110	−0·00075	−0·00563	−0·00726	Light scattered clouds, sudden gusts of cool breeze, clear and dry.
Makhdūmpur Pahoran, 13th March 1912.	−0·00198	−0·00162	−0·00649	−0·00816	Clear and dry, sudden gusts of cool breeze, afternoons dusty, dust-storm and rain once.
Kādipur Rau, 21st March 1912	−0·00301	−0·00268	−0·00731	−0·00942	Clear and dry afternoons, light scattered clouds.
Delhi, 1st April 1912 . .	−0·00216	−0·00252	−0·00773	−0·00985	Rain thrice, scattered clouds and strong gusts of cool breeze.

TABLE IV—(*contd.*)—No. 2 LEVELLING DETACHMENT.

Result of comparison of staves, season 1911-12.

Date and place of comparison.	Number of staff.				Remarks.
	20A.	20B.	16A.	16B.	
	Feet.	Feet.	Feet.	Feet.	
Dumpep, 14th December 1911	+0·00048	+0·00140	—0·00013	+0·00041	Scattered clouds, dry and cool.
Serrarim, 22nd December 1911	—0·00019	+0·00035	—0·00061	+0·00073	Cloudy, cool.
Cherrapunji, 29th December 1911.	—0·00071	—0·00027	—0·00085	+0·00001	Scattered clouds.
Therriaghāt, 3rd Jan. 1912 .	—0·00025	+0·00033	—0·00036	+0·00080	Clear.
Do., 5th Jan. 1912 .	—0·00075	—0·00024	—0·00084	+0·00053	Do.
Do., 8th Jan. 1912 .	—0·00007	+0·00013	—0·00064	+0·00073	Do.
Sylhet, 15th Jan. 1912 .	+0·00042	+0·00090	+0·00013	+0·00089	Scattered clouds.
Sheolamukh, 28th Jan. 1912	—0·00007	+0·00066	+0·00065	+0·00126	Clear, sky hazy.
Karīmganj, 7th Feb. 1912	+0·00060	+0·00062	+0·00033	+0·00145	Scattered clouds.
Salchapāra, 16th Feb. 1912	—0·00050	—0·00045	—0·00154	+0·00065	Sky hazy.
Barlekha, 27th Feb. 1912	—0·00068	—0·00084	—0·00168	+0·00008	Clear.
Samsernagar, 8th Mar. 1912	—0·00068	—0·00026	—0·00140	+0·00030	Do.
Srimangal, 19th Mar. 1912	—0·00141	—0·00097	—0·00183	—0·00027	Clear, cool breeze.
Shahji Bazār, 29th Mar. 1912	—0·00016	+0·00010	—0·00049	+0·00035	Scattered clouds.
Akhaura, 12th Apl. 1912	+0·00062	+0·00093	—0·00065	+0·00110	Clear.
Kamāla Sāgar, 21st Apl. 1912	+0·0009[illegible]	+0·00137	+0·00031	+0·00160	Cloudy.
Comilla, 30th Apl. 1912	+0·00068	+0·00107	+0·00020	+0·00219	Scattered clouds and warm.

TABLE IV—(*concld.*)—No. 3 LEVELLING DETACHMENT.

Result of comparison of staves, season 1911-12.

Date and place of comparison.		Number of staff.				Remarks.
		19A.	19B.	24A.	24B.	
		Feet.	Feet.	Feet.	Feet.	
Minbu,	3rd Dec. 1911	+0·00076	+0·00098	−0·00268	−0·00116	Scattered clouds.
Lēgaing,	10th Dec. 1911	+0·00070	+0·00026	−0·00396	−0·00269	Clear, cool breeze.
Salin,	18th Dec. 1911	+0·00046	+0·00034	−0·00356	−0·00213	Clear.
Linzin,	28th Dec. 1911	−0·00015	−0·00023	−0·00420	−0·00246	Light clouds.
Nwētamē,	5th Jan. 1912	+0·00019	+0·00039	−0·00313	−0·00213	Ditto.
Prome,	13th Jan. 1912	+0·00104	+0·00086	−0·00348	−0·00246	Cloudy.
Paunggyok,	22nd Jan. 1912	+0·00025	+0·00050	−0·00404	−0·00278	Clear.
Naungzyaye,	29th Jan. 1912	+0·00002	+0·00022	−0·00387	−0·00258	Scattered clouds.
Myenaung,	7th Feb. 1912	−0·00001	−0·00019	−0·00451	−0·00339	Clear.
Ngabatchaung,	14th Feb. 1912	−0·00027	−0·00003	−0·00491	−0·00373	Haze, cool breeze.
Ngawun,	23rd Feb. 1912	−0·00013	−0·00016	−0·00554	−0·00381	Clear.
Daunggyi,	2nd Mar. 1912	−0·00044	−0·00037	−0·00491	−0·00373	Light clouds.
Kyōnsha,	10th Mar. 1912	−0·00019	−0·00028	−0·00440	−0·00346	Haze.
Sekkaw,	21st Mar. 1912	+0·00014	+0·00020	−0·00460	−0·00308	Haze, cool breeze.
Yele,	29th Mar. 1912	+0·00003	+0·00008	−0·00453	−0·00351	Clear.
Sakangyi,	6th Apl. 1912	+0·00003	−0·00022	−0·00485	−0·00344	Do.
Maubin,	12th Apl. 1912	−0·00006	+0·00010	−0·00449	−0·00320	Haze.
Twante,	23rd Apl. 1912	−0·00013	+0·00023	−0·00538	−0·00374	Clear.
Seikgyi,	1st May 1912	−0·00012	−0·00010	−0·00515	−0·00366	Light clouds, cool breeze.
Rangoon Cantt.,	8th May 1912	+0·00019	+0·00015	−0·00447	−0·00321	Clear.

TABLE V.

Differences between levellers.

No. of detachment.	Section.	Difference. First—Second.	
			Feet.
No. 1 Levelling Detachment.	Line Khushāb-Shahpur .	At 9th mile or end of line .	+0·014
	Line Shahpur-Lahore .	„ 50th „	—0·006
	Ditto .	„ 100th „	+0·060
	Ditto .	„ 131st „ or end of line .	+0·063
	Line Sargodha-Multān .	„ 50th „	+0·059
	Ditto .	„ 100th „	+0·039
	Ditto .	„ 150th „	+0·028
	Ditto .	„ 172nd „ or end of line .	+0·003
No. 2 Levelling Detachment.	Line Dumpep to Comilla .	„ 50th „	+0·019
	Ditto .	„ 100th „	—0·019
	Ditto .	„ 150th „	—0·002
	Ditto .	„ 200th „	+0·062
	Ditto .	„ 235th „ or end of line .	+0·042
	Karīmganj to Silchār .	„ 35th „ „ „ .	+0·027
	Akhaura to Brahmanbaria	„ 13th „ „ „ .	+0·006
No. 3 Levelling Detachment.	Line Minbu-Paugma .	„ 53rd mile or end of line .	—0·002
	„ Paugma-Salin .	„ 21st „ „ „ .	—0·020
	„ Prome-Rangoon .	„ 50th „	+0·032
	Ditto .	„ 100th „	+0·101
	Ditto .	„ 150th „	+0·131
	Ditto .	„ 200th „	+0·026
	Ditto .	„ 268th „ or end of line .	+0·036

TABLE VI.

Statement showing levels and staves used in the field.

No. of detachment.	Name of levellers.	No. of levels.	Nos. of staves.	REMARKS.
No. 1 Levelling Detachment.	1st Mr. D. H. Luxa .	6727	05,02	
	2nd „ Jiya Lāl .	6726	01,03	
No. 2 Levelling Detachment.	1st „ O. N. Pushong	6724	20A, 20B	
	2nd „ T. F. Kitchen .	6724	20A, 20B	
	2nd „ N. Chuckerbutty	2697	16A, 16B	
No. 3 Levelling Detachment.	1st „ A. M. Talāti .	3	19A, 19B	
	2nd „ O. D. Jackson .	2626	24A, 24B	

TABLE VII.

Alphabetical List of Standard Bench-Marks.

Agra Fort	Connected.	Godhra	Connected.
Ahmedābād	Do.	Gorakhpur	Do.
Ahmednagar	Do.	Gwalior	Do.
Akola	Do.	Henzāda	Do.
Aligarh	Do.	Hinganghāt	Do.
Allahābād (Katcheri)	Do.	Hyderābād (Sind)	Do.
Allahābād (Scotch Kirk)	Do.	Jacobābād	Do.
Ambāla	Do.	Jhansi	Do.
Attock	Do.	Jhelum	Do.
Bahāwālpur	Do.	Jodhpur	Do.
Balasore	Do.	Jubbulpore	Do.
Bangalore	Do.	Karāchi	Do.
Bankipore	Do.	Khanpur	Do.
Bareilly	Do.	Kirkee	Do.
Barisāl	Not connected.	Lahore	Do.
Barōda	Connected.	Lucknow	Do.
Bassein	Not connected.	Ludhiāna	Do.
Belgaum	Connected.	Madras	Do.
Bellāry	Do.	Madura	Do.
Benares	Do.	Magwe	Do.
Berhampur (Ganjam)	Do.	Mandalay	Do.
Bezwāda	Do.	Meerut (P. W. D. Offices)	Do.
Bhagalpur	Do.	Meerut (St. John's Church)	Do.
Bhopāl (Edward's Museum)	Do.	Meiktila	Do.
Bhopāl (Arehra hill)	Do.	Mhow	Do.
Bijapur	Do.	Mirzapur	Do.
Bikanīr	Do.	Motihari	Do.
Bilaspur	Do.	Moulmein	Not connected.
Bolārum	Do.	Multān	Connected.
Burdwān	Not connected.	Mussooree	Do.
Calcutta	Connected.	Muttra	Do.
Calicut	Do.	Muzaffarnagar	Do.
Chittagong	Not connected.	Muzaffarpur	Do.
Cocanāda	Connected.	Myanaung	Do.
Comilla	Do.	Myitkyinā	Do.
Cuddapah	Do.	Mymensingh	Not connected.
Cuttack	Do.	Nagpur	Connected.
Dacca	Not connected.	Negapatam	Do.
Deesa	Connected.	Nellore	Do.
Dehra Dūn	Do.	Pegu	Do.
Delhi	Do.	Peshāwar	Do.
Deolāli	Do.	Poona (A. C. R. E.'s Office)	Do.
Dera Ismail Khān	Do.	Poona (St. Mary's Church)	Do.
Dhubri	Do.	Prome	Do.
Dhulia	Do.	Purnea	Do.
Dibrugarh	Do.	Raichur	Do.
Dinajpur	Do.	Raipur	Do.
Ferozepore	Do.	Rājkot	Do.
Fyzābād	Do.	Rangoon	Do.
Gauhati	Do.	Rāwalpindi	Do.
Ghazipur	Do.	Rewah	Do.

Alphabetical List of Standard Bench-Marks—contd.

Roorkee	Connected.	Silchār	Connected.
Sadiqganj	Do.	Sitapur	Do.
Sahāranpur	Do.	Sukkur	Do.
Salem	Do.	Surāt	Do.
Salin	Do.	Sylhēt	Do.
Sambalpur	Do.	Taunggyi	Not connected.
Satāra	Do.	Tinnevelly	Connected.
Saugor	Do.	Toungoo	Do.
Secunderābād	Do.	Trichinopoly	Do.
Shahjahānpur	Do.	Trimulgherry	Do.
Sholapur	Do.	Vizagapatam	Do.
Shwebo	Do.	Wuntho	Do.

PART VI.—MAGNETIC SURVEY.

No. 18 PARTY.
(*Vide* Index Map 11.)
BY CAPTAIN R. H. THOMAS, R.E.

PERSONNEL.
Imperial Officer.
Captain R. H. Thomas, R. E., in charge.
Provincial Officers.
Mr. H. P. D. Morton.
Mr. R. P. Ray.
Mr. N. R. Majumdar.
Mr. R. B. Mathur.
Lower Subordinate Service.
2 surveyors.
2 magnetic observers.
13 recorders.
1 computer.
1 clerk.

The present report deals with the work of the magnetic survey in 1911-12; it consists of :—

I. An account of the operations in the field and work in recess quarters.

II. A note on the observatories during the survey year 1911-12.

III. Tables of results, comprising preliminary values of the magnetic elements at field and repeat stations, in 1910-11 and the "quiet day" tabulations derived from the survey base stations.

I.—FIELD OPERATIONS AND RECESS WORK IN 1911-12.

1. *Work of the field detachments.*—The field season opened on October 23rd, 1911 and closed at the end of April 1912. The health of the party was satisfactory. Two field detachments each under a Provincial officer were employed on detail survey in Central India and Hyderābād State where the Deccan trap area exhibits considerable abnormalities; repeat stations in the vicinity of these areas were also visited.

During the season the values of the magnetic elements were determined at 78 new stations of the detail survey and 74 repeat stations including those visited by the officer in charge.

During the previous season four field detachments were employed. The reduction of the number of detachments this year is due to the strength of the party having been diminished by one Provincial officer, while another is being employed at head-quarters in the reduction of the declination data of the survey.

2. *Field work of the officer in charge.*—The officer in charge, (Captain Thomas, R.E.,) inspected the four survey base stations, and carried out comparative observations at each and at Alibāg magnetic observatory; in addition 37 repeat stations were reoccupied.

3. *Work during recess.*—The computation of the field work and the reduction and tabulation of the "quiet day" results from the base station records for 1911 have been completed.

From January 1912 the measurement of all days has been commenced, as proposed in last year's report; the hourly measurements are made and checked by the observatory staffs, while a further check is provided by independent measurements of the ordinates for 5 quiet days each month, which are made, as in previous years, by the computing section at Dehra Dūn.

Reduction of the declination data.

Good progress has been made with the reduction of the declination data of the survey, although owing to the unforeseen absence of the Provincial officer in charge of this section, who was required to hold charge of Toungoo observatory during a leave vacancy, this work could not be begun till late in

January 1912. The correction for diurnal variation has been practically completed, the amount of correction being deduced by means of a simplified empirical formula devised by Mr. J. deGraaff Hunter, M.A.; with this formula the correction is based upon the results of one, two, three or four base stations according to the number available at the date of any given field observation. The declination base lines are now being examined in conjunction with the comparative observations with field instruments to determine whether any correction in the direction of smoothing the curve of observed values is justified, after which the corrections for disturbance and secular change, (for reduction to the selected epoch), will be applied.

It may be noted that the four base stations agree in indicating that secular change in declination is increasing.

Corrections for disturbance have been tentatively applied to all observations at repeat and re-observed stations to obtain approximate values of secular change ; it was found that while the permanently marked stations in all cases and the unmarked stations in undisturbed localities gave consistent results repeat observations at unmarked stations in regions of disturbance were quite unreliable, small errors in re-siting the instrument introducing varying " station errors ".

4. *Instrumental differences in H. F.*—The officer in charge has been mainly occupied during the recess season in continuing the investigation of the instrumental differences in H. F.

In last year's report it was observed that the observed discrepancies were for the most part to be attributed to " personal error " in the vibration observations, and further, that, provided the changes in the constants liable to alter, *viz.*:—the moment of inertia and the distribution constants were accurately known, there seemed no reason for the instrumental differences to vary at all.

Changes in the distribution constants were dealt with in last year's report where it was shown that changes had occurred in the standard and one field instrument only.

It remained to determine the probable changes in the moment of inertia and the probable personal errors for all the instruments for the period 1902-1910, during which the vibration experiments had been made only by the eye and ear method.

As regards the moment of inertia, there existed some uncertainty as to the initial values for the field instruments, owing to an unexplained change in the length of the inertia bar, when the latter was remeasured in 1904 : the moment of inertia of the standard, however, had been measured throughout with another bar and the changes from time to time were known with considerable accuracy; there was a steady fall in the value equivalent to a reduction of the observed value of H. F. by 32γ in 1912.

Reliable values of the moment of inertia of the field magnets are available since 1906 when a new standard bar was obtained ; the values show slight decreases since that year, in each case considerably less than in the standard. Now since the diminution in value in the standard was sensibly uniform over the whole period 1902-12 there was every reason to suppose that the smaller changes in the field magnets would also be uniform and values for 1902 were obtained therefore by an extension of the curves for 1906-12.

These values were further checked by comparing the differences of the magnetograph base line deduced from the observed values with each instru-

ment at Dehra Dūn at the time of comparative observation in 1902 and 1910, when the chronograph was used for the vibration experiments and the resulting values could be considered to be free from "personal error."

The orgiinally accepted values of π^2 K had been used in the computations in both comparisons and if other sources of error could be assumed to have been eliminated, it was clear that any variation in the differences would be a measure of the relative changes of π^2 K.

The following are the differences of base line found for the period 1902-10:—

	17 (Survey standard).	3A.	4A.	5A.	6A.
1902	33245	268	260	274	259
1910	33070	074	070	079	064
Difference, 1902-1910	175	194	190	195	195

This shows that the change of π^2 K in for example No. 6 instrument during the period 1902-10 has been equivalent to 20γ less than the fall in the standard instrument and knowing the actual fall in the standard to be equivalent to 27γ, the resulting change in the value of π^2 K in No. 6 for the same period is equivalent to 7γ. Further the values with the standard corrected for change in π^2 K are in 1902 ·33234 c.g.s. and in 1910 ·33032 c.g.s., a difference of 202γ : the change of 7γ in 6 should be applied, to give the same difference; it is known that the correction in 1910 is -2γ and consequently the 1902 value requires to be corrected by $+5\gamma$ on account of π^2 K. The curve for 1906—12 extended to 1902 gives a correction of $+5\gamma$: the assumption of a uniform decrease in π^2 K seems therefore reasonable.

Changes in the moment of inertia having been determined the question of "personal error" remained to be dealt with. Owing to frequent changes of moment in some of the field magnets, this question has proved more complex than was anticipated and though at the time of writing the investigation is practically completed, time does not admit of the inclusion of the results in this report.

The instrumental differences have been found to be as follows, after inclusion of the Q term :—

17—1—11γ
2—83γ
3—42γ
4—15γ
5—44γ
6—30γ
10—40γ

5. *Programme for 1911-12.*—During the ensuing field season three detachments will be employed in the field, one under the officer in charge and two under Provincial officers.

The officer in charge will inspect the survey observatories, observe at repeat stations and carry out a general magnetic survey of Ceylon.

One detachment will carry on the detailed survey in Hyderābād and Berār, the third will be occupied throughout the season in visiting repeat stations.

6. *Results published in this report.*—Tables showing the approximate values (uncorrected) of the magnetic elements at the field and repeat stations in 1911-12 are appended, with an index chart showing the progress of the magnetic survey to date.

The tabulations of the "quiet day" results at the four observatories are published for 1911.

II.—WORKING OF THE OBSERVATORIES.

A.—DEHRA DŪN OBSERVATORY.

1. *General Remarks on working.*—The observatory remained in charge of magnetic observer Shri Dhar throughout the year.

The magnetographs were dismantled at the end of May 1912 when the repairs to the underground room referred to in last year's report were carried out; the instruments were re-erected on the 9th of June 1912.

It is satisfactory to note that the room remained quite dry during the past rainy season.

The opportunity was taken to thoroughly clean the instruments, during which the quartz fibre suspension of the H. F. instrument was unfortunately broken; a new fibre was mounted and the temperature coefficient redetermined in October 1912. The resulting value was $\pm$ 12·6γ for $\mp$ 1°C, which agrees with the previous value.

The changes in the H. F. during the temperature experiment were determined by two magnetometers, deflection observations being made at 22·5 cms. every 7½ minutes alternately with each instrument.

The temperature coefficient of the V. F. magnetograph was determined at the same time and the value obtained, *viz.*: $\pm$ 5·2 for $\mp$ 1°F, agrees with those obtained in March 1907.

The definition of the curves has been greatly improved by fitting stops of smaller aperture than those previously used.

2. *Mean values of H. F. and declination constants.*—The table below gives the mean monthly values of magnetic collimation, the distribution coefficients P_1 and P_2 and the mean values of m_o used in the computation of the results with the survey standard for 1911.

In May 1911 there was an apparent fall in the observed value of m_o which could only be accepted on the hypothesis of instrumental change; on further investigation in July 1911 it was found that the apparent fall was due to an error in the thermometer used in the vibration experiment, and another thermometer was therefore substituted.

From the "Chronographic" comparisons this thermometer error seems to have developed between February 1910 and May 1911, and it would therefore appear desirable to have two thermometers fitted to a magnetometer, at any rate for observatory work.

Mean values of the constants of the Magnetometer No. 17 in 1911.

MONTHS.	DECLINATION CONSTANTS. Mean magnetic collimation.	H. F. CONSTANTS. Mean values of P's. $P_{1\cdot 3}$	$P_{1\cdot 3}$	Accepted value of P_1's	Accepted value of P_2's	Accepted value of m	REMARKS.
January	—9′: 37″	7·10	7·73	7·17 throughout.	7·80 throughout.	893·31	
February	—9′: 38″	7·02	7·70				
March	—9′: 23″	7·08	7·88				
April	—9′: 24″	7·11	7·94			893·27	

Mean values of the constants of the Magnetometer No. 17 in 1911.

Months.	Declination constants. Mean magnetic collimation.	H. F. Constants. Mean values of P's. $P_{1\cdot2}$	$P_{2\cdot3}$	Accepted value of $P_{1\cdot2}$	Accepted value of $P_{2\cdot3}$	Accepted value of m.	Remarks.
May . . .	—9′: 27″	7·24	7·50			893·27	
June . . .	—9′: 23″	7·24	7·76				
July . . .	—9′: 22″	7·12	7·88				
August . . .	—9′: 18″	7·16	7·77				
September . .	—9′: 24″	7·15	7·68			893·23	
October . . .	—9′: 24″	7·11	7·91				
November . .	—9′: 27″	7·19	7·76				
December . .	—9′: 26″	7·23	7·81				

3. ***Mean base line values.***—The table below gives the mean values of the H. F. and declination base lines, actually used to obtain the values of H. F. etc., given in the tables attached to this report.

These values of H. F. and V. F. should be regarded as preliminary only, as they will be corrected subsequently for "personal error" and the Q term, they have been obtained in the same way as those of previous years, with which they are comparable.

The V. F. base lines are not given, as irregular changes are to be expected in these instruments which require frequent cleaning and readjustment.

Base line values of Magnetographs in 1911.

Months, 1911.	Declination. Mean value of Base line.	Declination. Base line accepted.	Declination. Remarks.	Horizontal Force. Mean value of Base line.	Horizontal Force. Base line accepted	Horizontal Force. Remarks.
	° ′	° ′			·32996	1st to 7th.
January . . .	1 : 44·4	1 : 44·4		·32999	·32999	8th to 22nd.
					·33002	23rd to 31st.
					·33002	1st to 7th.
February . .	1 : 44·5	1 : 44·5		·33005	·33005	8th to 21st.
					·33008	22nd to 28th.
					·33008	1st to 7th.
March . .	1 : 44·8	1 : 44·8		·33010	33011	8th to 22nd.
					·33014	23rd to 31st.
					·33014	1st to 7th.
April . .	1 : 45·0	1 : 45·0		·33016	·33017	8th to 22nd.
					·33020	23rd to 30th.

Base line values of Magnetographs in 1911.

MONTHS, 1911.	DECLINATION.			HORIZONTAL FORCE.		
	Mean value of Base line.	Base line accepted.	REMARKS.	Mean value of Base line.	Base line accepted.	REMARKS.
	° ′	° ′				
May . . .	1 : 45·0	1 : 45·0		·33022	·33022	
June . . .	1 : 45·3	1 : 45·3		·33019	·33019	
July . . .	1 : 45·2	1 : 45·2		·33016	·33016	
					·33014	1st to 7th.
August . . .	1 : 45·2	1 : 45·2		·33012	·33012	8th to 22nd.
					·33010	23rd to 31st.
					·33008	1st to 7th.
September . .	1 : 45·1	1 : 45·1		·33005	·33005	8th to 22nd.
					·33002	23rd to 30th.
October . . .	1 : 45·2	1 : 45·2		·33001	·33001	
November . .	1 : 45·4	1 : 45·4		·33002	·33002	
December . .	1 : 45·2	1 : 45·2		·33005	·33005	

4. *Mean scale values and temperature ranges.*—The mean scale values for 1911, for an ordinate of 0·04 inches, were as follows : H. F. 4·12γ, V. F. 4·1γ to 4·7γ, Declination 1′·03.

The mean temperature for the year was 27°·2 C, the maximum and minimum monthly values being 27°·3 C and 27°·1 C; the temperature of reduction is 27° C.

5. *Mean monthly values and secular change, 1910-11.*—The following table gives the mean monthly values of the magnetic elements for 1910-11 and the secular changes during that period deduced therefrom :—

Secular changes at Dehra Dūn in 1910-11.

MONTHS.	HORIZONTAL FORCE ·33000 C. G. S.+			DECLINATION E. 2°+			DIP N. 43°+			VERTICAL FORCE ·31000 C. G. S.+		
	1910.	1911.	Secular change.	1910.	1911.	Secular change.	1910.	1911.	Secular change.	1910.	1911.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January . . .	263	240	−23	33·4	30·5	−2·9	52·0	58·9	+6·9	972	1,078	+106
February . .	261	238	−23	33·4	30·2	−3·2	52·2	59·8	+7·6	974	1,094	+120
March . . .	266	246	−20	33·3	30·3	−3·0	52·4	59·7	+7·3	982	1,100	+118
April . . .	256	241	−15	32·2	30·0	−2·2	53·1	60·7	+7·6	986	1,114	+128
May . . .	270	243	−27	32·2	29·5	−2·7	53·5	61·4	+7·9	1,006	1,130	+124
June . . .	264	247	−17	31·8	29·3	−2·5	54·3	62·0	+7·7	1,015	1,143	+128
July . . .	269	243	−26	31·3	29·0	−2·3	54·8	62·4	+7·6	1,030	1,147	+117
August . . .	253	241	−12	31·4	28·8	−2·6	55·6	62·9	+7·3	1,029	1,154	+125
September . .	255	235	−20	31·1	28·4	−2·7	56·0	62·7	+6·7	1,039	1,146	+107
October . . .	241	229	−12	31·3	28·3	−3·0	57·7	63·9	+6·2	1,056	1,163	+107
November . .	243	231	−12	30·9	28·0	−2·9	58·1	64·6	+6·5	1,067	1,176	+109
December . .	248	222	−26	30·4	27·6	−2·8	58·1	65·3	+7·2	1,071	1,181	+110
Means .	257	238	−19	31·9	29·2	−2·7	54·8	63·0	+7·2	1,019	1,136	+117

B.—BARRACKPORE OBSERVATORY.

1. *General Remarks on working.*—Magnetic Observer K. N. Mukerji remained in charge throughout the year except for two months during which he was on sick leave when Abdul Majid officiated.

The magnetographs worked satisfactorily.

Sanction has been accorded to the provision of suitable quarters for the recorder permanently allotted to the observatory, since the measurement of "all days" was undertaken.

2. *Mean values of constants.*—The following table gives the monthly mean values of magnetic collimation, the distribution co-efficients of P_1 and P_2 and the moment m_0 of magnetometer No. 20 in 1911.

Mean values of the constants of the Magnetometer No. 20 in 1911.

MONTHS.	DECLINATION CONSTANTS. Mean magnetic collimation.	HORIZONTAL FORCE CONSTANTS. Mean values of P's. $P_{1\cdot 2}$	$P_{2\cdot 3}$	Accepted value of $P_{1\cdot 2}$	Accepted value of $P_{2\cdot 3}$	Accepted value of m_0	REMARKS.
January	—7 ′: 57″	6·81	7·63	6·82 throughout.	7·61 throughout.	940·22	
February	7 : 56	6·79	7·65			940·16	
March	7 : 56	6·75	7·56			940·10	
April	7 : 51	6·89	7·69			940·04	
May	7 : 53	6·77	7·60			939·98	
June	7 : 51	6·82	7·69			939·92	
July	7 : 48	6·77	7·49			939·86	
August	7 : 55	6·89	7·61			939·80	
September	7 : 48	6·82	7·45			939·74	
October	7 : 50	6·87	7·91			939·68	
November	7 : 54	6·83	7·51			939·62	
December	7 : 57	6·89	7·59			939·56	

3. *Mean values of base lines.*—The table below gives the mean monthly base lines of the H. F. and Declination instruments actually used: those of the V. F. are not shown:—

Abstract of Base Line value of Magnetographs in 1911.

MONTHS, 1911.	DECLINATION. Mean value of Base line.	Accepted value of Base line.	REMARKS.	HORIZONTAL FORCE. Mean value of Base line.	Accepted value of Base line.	REMARKS.
	° ′	° ′				
January	—0 : 4·5	—0 : 4·5		·37039	·37039	
February	0 : 4·5	0 : 4·5		·37049	·37044	
March	0 : 4·4	0 : 4·4		·37059	·37049	
April	0 : 4·2	0 : 4·2		·37044	·37054	
May	0 : 4·2	0 : 4·2		·37066	·37059	
June	0 : 4·2	0 : 4·2		·37063	·37063	
July	0 : 4·1	0 : 4·1		·37063	·37063	
August	0 : 4·0	0 : 4·0		·37060	·37064	
September	0 : 4·0	0 : 4·0		·37072	·37065	
October	0 : 4·2	0 : 4·2		·37056	·37065	
November	0 : 4·1	0 : 4·1		·37069	·37065	
December	0 : 3·9	0 : 3·9		·37065	·37065	

4. ***Mean scale values and temperature range.***—The mean scale values for the year for an ordinate of 0·04 inch were: for H. F. 4·86γ, V. F. 4·6γ, Declination 1′·03.

The mean temperature for the year was 32°·3 C with maximum and minimum values of 33°·1 C and 31°·9 C ; the temperature of reduction is 31°C.

5. ***Mean monthly values and secular change.***—The following table gives the mean monthly values of the magnetic elements in 1910-11 with the secular change for that period.

The values of H. F. and V. F. are preliminary only : they will be subsequently corrected for "personal error", Q term and difference from the Survey standard.

Secular changes at Barrackpore in 1910-11.

MONTHS.	HORIZONTAL FORCE ·37000 C. G. S. +			DECLINATION E. 0° +			DIP N. 30° +			VERTICAL FORCE ·22000 C. G. S. +		
	1910.	1911.	Secular change.	1910.	1911.	Secular change.	1910.	1911.	Secular change.	1910.	1911.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January . . .	318	321	+ 3	56·1	50·3	—5·8	40·3	43·1	+2·8	133	175	+42
February . .	317	327	+10	57·6	52·0	—5·6	40·9	43·5	+2·6	141	185	+44
March . . .	323	339	+16	57·4	51·7	—5·7	40·8	44·0	+3·2	143	199	+56
April . . .	320	336	+16	56·6	51·2	—5·4	41·6	44·5	+2·9	153	205	+52
May . . .	331	335	+ 4	56·1	50·7	—5·4	41·9	44·4	+2·5	164	203	+39
June . . .	330	342	+12	55·8	50·0	—5·8	42·1	45·1	+3·0	167	217	+50
July . . .	337	337	0	55·2	49·7	—5·5	42·0	45·5	+3·5	168	220	+52
August . . .	336	336	0	54·5	49·4	—5·1	42·9	46·2	+3·3	181	230	+49
September . .	341	334	− 7	54·2	48·9	—5·3	43·0	47·0	+4·0	186	240	+54
October . . .	327	335	+ 8	54·0	48·2	—5·8	43·6	47·4	+3·8	187	247	+60
November . .	331	346	+15	53·5	47·8	—5·7	44·1	47·4	+3·3	196	254	+58
December . .	341	351	+10	52·8	47·3	—5·5	43·5	47·6	+4·1	193	260	+67
Means . .	329	337	+ 8	55·5	49·9	—5·6	42·2	45·5	+3·3	168	220	+52

C.—TOUNGOO OBSERVATORY.

1. *General Remarks on working.*—Mr. R. P. Ray was in charge of the observatory until 20th January 1912 when he was relieved by Surveyor K. K. Dutta who was in charge for the remainder of the year.

The officer in charge inspected the observatory early in December 1911 and readjusted the V. F. and Declination magnetographs. The temperature coefficient of the V. F. instrument was redetermined and found to be ∓ 2 9 γ per ∓ 1° F ; the value previously determined in July 1911 was ± 0. 4 γ per

$\mp$ 1° F; this change is accounted for by a slight displacement of the temperature compensation bar during the readjustment.

The H. F. and Declination magnetographs worked well throughout, the latter being readjusted only because owing to the effect of secular change the curve was approaching the edge of the sensitized paper.

The V. F. magnetograph gave frequent trouble owing to the balance being somewhat unstable; Lieutenant Morshead remedied this defect in the previous year by lowering the centre of gravity at the expense of the scale value which was raised to 16·5 γ; this was reduced in July 1911 to 5·0γ, raised again by the observer at the end of September to 11·3 γ and reduced in December 1911 to 4·8γ.

Changes of zero have again given trouble during the present year, but as the similar instruments at the other observatories give little trouble with scale values of about 5 γ it is hoped that the necessary stability will be obtained by shifting the knife edge of the magnet a little further from the edge of the agate plane upon which it rests (of Narrative Report, 1906-07).

2. *Mean values of Declination and H. F. constants.*—The table below gives the mean monthly observed values of magnetic collimation, observed and accepted values of the distribution constants P_1 and P_2 and the magnetic moment m_0; the accepted values are those used in computing the monthly mean values.

It will be noticed that the monthly values of magnetic collimation show considerable fluctuations for which no cause can be at present assigned with any certainty.

The observed values of m_0 show a rapid fall as during previous years.

Mean values of the Constants of the Magnetometer No. 19 in 1911.

Months.	Declination constants. Mean magnetic collimation.		Remarks.	H. F. Constants. Mean values of P's. $P_{1\cdot2}$	$P_{2\cdot3}$	Accepted value of $P_{1\cdot2}$	Accepted value of $P_{2\cdot3}$	Accepted value of m_0	Remarks.
	′	″							
January	3	20	To 11th.	8·51	9·32	8·48 throughout.	9·13 throughout.	892·65	
	0	17	From 18th.						
February	0	18		8·46	8·92			892·57	Up to 18th March.
March	0	31		8·54	9·01			892·43	March 21st to end.
April	2	57	To 7th.						
	1	53	10th to 17th.	8·48	9·13			892·18	
	0	19	From 18th.						
May	1	33		8·53	9·11			892·05	
June	1	10		8·53	9·06			891·87	1st June to 20th July.
July	0	18		8·44	8·98			...	
August	0	26		8·49	9·08			891·37	22nd July to 20th September.
September	0	55		8·45	8·89			891·17	21st September to 30th.
October	0	35		8·47	9·12			891·06	
November	1	44	To 15th.						
	2	31	From 17th.	8·36	9·47			890·88	
December	2	25		8·37	9·45			890·69	2nd to 7th.
								889·99	For 9th.
								886·64	19th to 23rd.
								886·05	26th to 30th.

3. *Mean Base Line values.*—The following table gives the observed and accepted Base Lines of the H. F. and Declination magnetographs.

The observed declination base lines show a variation which though smaller than in 1909 and 1910 is still larger than is to be expected; the comparisons with No. 10 magnetometer in 1911 and 1912 show that the change in base line was negligible before the readjustment in December 1911 and the base line for the whole period has for this reason been taken as the same as in December 1910.

It seems probable that the defects in the wooden magnetometer box, referred to in last year's report, have not yet been effectually remedied and the instrument will be carefully examined during the next inspection of the observatory.

The difference between the accepted and observed Base Lines in H. F. is due partly to the smoothing of the curve of m_o and partly to a correction of -19γ to reduce to the magnet No. 19 which was used in the earlier years of the observatory.

Base Line values of Magnetographs in 1911.

MONTHS, 1911.	DECLINATION.			HORIZONTAL FORCE.		
	Mean value of Base line.	Base line accepted.	REMARKS.	Mean value of Base line.	Base line accepted.	REMARKS.
	° ′					
January	−0 : 7·9	−0° : 9′·1 up to 10th December. −0° : 29′·7 from 12th „		·38518	·38497	
February	8·3			·38517	·38496	
March	8·6		Up to 8th.	·38523	·38496	
	7·7		From 10th.			
April	7·0			·38516	·38495	
May	7·2			·38514	·38489	
June	7·3			·38510	·38489	
July	6·8			·38508	·38489	Up to 21st.
					·38486	From 22nd.
August	7·9		To 9th.	·38502	·38485	Up to 15th.
	6·5		From 11th.		·38480	From 16th.
September	7·7		To 15th.	·38498	·38480	1st to 7th.
	8·6		From 19th.		·38477	8th to 22nd.
					·38474	From 23rd.
October	8·1			·38492	·38473	
November	7·9			·38481	·38467	
December	8·5		To 9th.	·38487	·38462	
	29·1		From 18th when instrument was re-adjusted.			

4. ***Mean scale values and temperature range.***—The mean scale values in 1910 are as follows :—

H. F.	5·43γ	for an ordinate of 0·04 inch.
V. F.	16·5γ to 4·8γ	
Declination	1'·04	

The mean temperature for the year was 89°·1 F. with maximum and minimum monthly values of 89°·3 C and 88°·9 C; the temperature of reduction is 89° F.

5. *Secular change, 1910-11.*—The table below gives the mean monthly values of the magnetic elements for 1910 and 1911 and the secular change during this period :—

Secular changes at Toungoo in 1910-11.

MONTHS.	HORIZONTAL FORCE ·38000 C. G. S. +			DECLINATION E. 0° +			DIP N. 23° +			VERTICAL FORCE ·16000 C. G. S.+		
	1910.	1911.	Secular change.	1910.	1911.	Secular change.	1910.	1911.	Secular change.	1910.	1911.	Secular change.
	γ	γ	γ	'	'	'	'	'	'	γ	γ	γ
January . . .	782	833	+ 51	27·3	21·8	—5·5	1·6	2·4	+0·8	483	515	+ 32
February . . .	783	836	+ 53	26·9	21·3	—5·6	2·0	2·5	+0·5	489	519	+ 30
March . . .	793	849	+ 56	26·6	21·2	—5·4	1·8	2·6	+0·8	491	525	+ 34
April . . .	788	848	+ 60	25·9	20·7	—5·2	2·6	2·7	+0·1	499	526	+ 27
May	796	845	+ 49	25·6	20·0	—5·6	2·4	3·0	+0·6	500	528	+ 28
June . . .	797	858	+ 61	25·3	19·7	—5·6	2·0	3·3	+1·3	495	538	+ 43
July	809	860	+ 51	24·8	19·0	—5·8	2·1	3·2	+1·1	502	537	+ 35
August . . .	809	858	+ 49	24·1	18·5	—5·6	2·3	3·0	+0·7	504	534	+ 30
September . .	811	856	+ 45	23·6	18·1	—5·5	2·1	2·7	+0·6	501	530	+ 29
October . . .	799	860	+ 61	23·4	17·6	—5·8	2·2*	3·8	+1·6	498	546	+ 48
November . .	815	866	+ 51	22·9	17·0	—5·9	1·8*	3·7	+1·9	500	548	+ 48
December . .	834	861	+ 27	22·3	16·5	—5·8	2·2*	2·9	+0·7	513	535	+ 22
Means . . .	801	853	+ 52	24·9	19·3	—5·6	2·1	3·0	+0·9	498	532	+ 34

* Mean observed value of Dip.

D.—KODAIKĀNAL OBSERVATORY.

1. *General Remarks on working.*—S. S. Ramaswami Aiyangar was in charge throughout the survey year 1910-11, except for three months when he was relieved by K. K. Dutta.

Thanks are due to the Director, Solar Physics Observatory, for his cordial assistance in all matters connected with the magnetic work; since May of the present year, he has kindly placed his electric-chronograph at the disposal of the magnetic observer for periodical determinations of "personal error."

The officer in charge inspected the observatory in March 1912 when all the magnetographs were readjusted; in the H. F. and Declination instruments the curve had approached the edge of the sensitized paper owing to secular changes.

2. *H. F. and Declination constants.*—The table below gives the monthly mean values of the magnetic collimation, the distribution constants P_1 and P_2 and the accepted values of the magnetic moment m_o: the accepted values are those used in computing the monthly mean values:—

Mean values of the constants of the Magnetometer No. 16 in 1911.

MONTHS.	DECLINATION CONSTANTS.	H. F. CONSTANTS.					REMARKS.
	Mean magnetic colli-mation.	MEAN VALUES OF P's.				Accepted value of m^o	
		$P_{1·2}$	$P_{2·3}$	Accepted value of $P_{1·2}$	Accepted value of $P_{2·3}$		
	′ ″						
January . . .	−2 : 34	6·94	9·03	6·92 throughout.	8·75 throughout.	917·87	
February . . .	−2 : 34	6·90	8·59				
March	−2 : 34	6·90	8·77			917·63	
April	−2 : 38	6·90	8·72			917·43	
May	−2 : 37	6·93	8·72				
June	−2 : 30	6·88	9·13				
July	−2 : 36	7·10	8·68				
August	−2 : 35	6·81	8·85				
September . . .	−2 : 35	6·80	8·57				
October	−2 : 40	6·85	8·62				
November . . .	−2 : 36	6·92	8·79				
December . . .	−2 : 38	6·93	8·61				

3. *Mean Base Line Values.*—The table below gives the mean monthly observed and accepted values of the H. F. and Declination base lines: the accepted values have been used in computing the monthly mean values.

In last year's report it was noted that the apparent changes of m_o during 1910 had to be disregarded as they were not substantiated by the resulting monthly mean values of H. F. and the base line was computed with the value of m_o found at the beginning of the year. For the same reason the observed values of m_o in 1911 have been rejected; from the comparisons made with magnetometer No. 10 in 1910-11 and 1911-12 the Base Line value is shown to have fallen by 13γ during twelve months and the accepted monthly base lines given below have therefore been derived from that for December 1910 by applying a gradual fall of 1γ per month.

The H. F. base lines can then only be considered provisional and liable to subsequent correction.

Abstract of Base Line values of Magnetographs in 1911.

MONTHS.	DECLINATION.		HORIZONTAL FORCE.	
	Mean value of Base line.	Base line accepted.	Mean value of Base line.	Base line accepted.
	° ′	° ′		
January	1 : 33·0	1 : 33·0	·36914	·36948
February	1 : 32·6	1 : 32·6	·36911	·36947
March	1 : 32·5	1 : 32·5	·36908	·36946
April	1 : 32·6	1 : 32·6	·36894	·36945
May	1 : 32·7	1 : 32·7	·36897	·36944
June	1 : 32·8	1 : 32·8	·36896	·36943
July	1 : 32·6	1 : 32·6	·36895	·36942
August	1 : 32·7	1 : 32·7	·36893	·36941
September	1 : 32·9	1 : 32·9	·36883	·36940
October	1 : 33·0	1 : 33·0	·36892	·36939
November	1 : 33·1	1 : 33·1	·36885	·36938
December	1 : 33·0	1 : 33·0	·36886	·36937

4. *Mean scale values and temperature range.*—The mean scale values for 1911 are as follows:—

H. F. 6·14γ

V. F. { 5·4γ to 5·9γ } for an ordinate of 0·04 inch.

Declination 1′·03

The mean temperature was 18°·3 C with maximum and minimum monthly values of 18°·7 C and 17°·8 C; the temperature of reduction is 19° C.

5. *Secular change, 1910-11.*—The following table gives the mean monthly values of the magnetic elements for 1910 and 1911 with the secular change deduced during the interval :—

Secular changes at Kodaikānal in 1910-11.

MONTHS.	HORIZONTAL FORCE ·37000 C. G. S. +			DECLINATION W. 0°+			DIP N. 3° +			VERTICAL FORCE ·02000 C. G. S. +		
	1910.	1911.	Secular change.	1910.	1911.	Secular change.	1910.	1911.	Secular change.	1910.	1911.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January . .	481	504	+23	52·5	58·1	+5·6	41·8	48·8	+7·0	422	499	+77
February . .	469	498	+29	53·0	57·9	+4·9	43·1	49·6	+6·5	435	508	+73
March . . .	480	511	+31	53·3	58·2	+4·9	43·4	50·0	+6·6	439	513	+74
April . . .	473	508	+35	54·2	58·8	+4·6	43·7	50·7	+7·0	442	520	+78
May . . .	483	507	+24	54·7	59·4	+4·7	44·1	51·0	+6·9	446	524	+78
June . . .	482	512	+30	55·0	60·2	+5·2	45·2	52·0	+6·8	458	535	+77
July . . .	484	515	+31	55·3	60·2	+4·9	45·9	52·2	+6·3	466	538	+72
August . . .	486	519	+33	55·7	60·7	+5·0	46·4	52·7	+6·3	472	544	+72
September . .	494	528	+34	55·9	61·5	+5·6	46·7	52·9	+6·2	476	547	+71
October . .	479	526	+47	56·2	62·0	+5·8	47·2	54·2	+7·0	481	560	+79
November . .	492	530	+38	57·2	62·5	+5·3	47·6	54·8	+7·2	486	567	+81
December . .	511	527	+16	57·4	62·9	+5·5	47·8	55·2	+7·4	489	571	+82
Means . .	485	515	+30	55·0	60·2	+5·2	45·2	52·0	+6·8	459	536	+77

III.—TABLES OF RESULTS.

INDEX TO TABLES.

A. Mean values of the magnetic elements at the observatories for 1911.
B. Classification of curves and dates of magnetic disturbances in 1911.
C. Tables of results at Dehra Dūn.
D. „ „ Barrackpore.
E. „ „ Toungoo.
F. „ „ Kodaikānal.

For each observatory the following tables are given :—

1. Hourly means, (corrected for temperature), of Declination, H. F., V. F. and Inclination from 5 selected quiet days per month.
2. Diurnal inequality of each element deduced from 1.

G. Preliminary values of the magnetic elements at field and repeat stations in 1911-12.

A.—Mean values of the magnetic elements at observatories in 1911.

Observatory.	Latitude and Longitude.	Dip.	Declination.	H. F.	V. F.
	° ′ ″	° ′	° ′	C. G. S.	C. G. S.
Dehra Dūn	30 19 19 N 78 3 19 E	N 44 2·0	E 2 29·2	·33238	·32136
Barrackpore	22 46 29 N 88 21 39 E	N 30 45·5	E 0 49·9	·37337	·22220
Toungoo	18 55 45 N 96 27 3 E	N 23 3·0	E 0 19·3	·38853	·16532
Kodaikānal	10 13 50 N 77 27 46 E	N 3 52·0	W 1 0·2	·37515	·02536

D=Dehra Dûn . { Lat. 30° 19' 19" N. Long. 78° 3' 19" E.

B=Barrackpore . { Lat. 22° 46' 29" N. Long. 88° 21' 39" E.

B.—Classification of curves and dates of Magnetic disturbances in 1911.

T=Toungoo . { Lat. 18° 55' 45" N. Long. 96° 27' 3" .

K=Kodaikanal . { Lat. 10° 13' 50" N. Long. 77° 27' 46" E.

Date.	January.				February.				March.				April.				May.				June.			
1911	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K
1	C	C	C	C	S	S	S	S	S	S	S	S	C	—	C	C	C	C	C	C	S	S	S	S
2	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C
3	S	S	S	S	S	S	S	S	S	C	C	C	S	S	S	S	C	C	C	S	(C)	(C)	(C)	(C)
4	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	S	(C)	(C)	(C)	(C)	S	S	S	S
5	S	S	S	C	S	S	S	S	M	M	S	S	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S
6	S	S	S	C	S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	S
7	C	C	C	C	S	S	S	S	C	C	C	—	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	—
8	S	C	C	C	S	S	S	S	S	S	S	—	M	M	M	S	S	S	S	S	C	C	C	—
9	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	M	M	M	M	(C)	(C)	(C)	(C)	C	C	C	—
10	S	S	S	S	S	S	S	S	C	C	C	C	M	M	S	S	S	S	S	C	S	S	S	—
11	S	S	S	S	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	S	S	S	—
12	(C)	(C)	(C)	(C)	C	C	C	C	(C)	(C)	(C)	(C)	C	C	C	S	S	S	S	S	S	S	S	—
13	S	S	S	C	S	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	—
14	(C)	(C)	(C)	(C)	M	S	S	S	S	S	S	S	—	C	C	C	S	S	S	S	S	S	S	—
15	S	C	C	C	C	C	C	C	S	S	S	C	—	C	C	C	S	S	S	S	S	S	S	—
16	S	S	S	S	S	S	S	C	S	S	S	S	M	S	S	S	S	S	S	S	S	S	S	—
17	(C)	(C)	(C)	(C)	S	S	S	S	(C)	(C)	(C)	(C)	—	S	S	S	S	S	S	S	C	C	C	—
18	S	S	S	S	S	S	C	S	(C)	(C)	(C)	(C)	—	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)
19	C	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	C	C	C	C
20	C	C	C	C	(C)	(C)	(C)	(C)	G	G	G	G	S	S	S	S	S	S	S	S	—	S	S	S
21	S	S	S	C	G	M	M	S	M	M	M	S	S	S	S	S	S	S	S	S	—	S	S	S
22	C	C	C	C	M	M	S	S	S	S	S	S	S	S	S	S	S	S	S	S	—	S	S	S
23	(C)	(C)	(C)	(C)	M	M	S	S	M	S	S	S	S	S	S	S	S	C	C	S	S	S	S	S
24	M	M	S	S	S	S	S	S	S	S	S	S	S	S	S	S	(S)	(C)	(C)	(C)	S	S	S	S
25	M	S	M	S	S	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C
26	S	S	S	S	S	S	S	S	S	S	S	C	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C
27	S	S	C	C	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C
28	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	(S)	(C)	(C)	(C)	S	S	S	S
29	S	C	C	C	..	...	...	...	S	S	S	S	S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)
30	S	C	C	C	...	...	...	...	S	C	C	C	S	S	S	S	S	S	S	C	C	C	C	C
31	S	S	S	S	...	...	...	...	S	S	S	S	...	...	...	...	S	S	S	S	...	...	...	..
C	9	13	14	18	7	7	8	8	10	12	12	13	9	10	11	10	8	11	11	11	13	13	13	9
S	20	17	16	13	17	18	19	20	17	16	17	15	13	16	17	19	23	20	20	20	14	17	17	10
M	2	1	1	...	3	3	1	...	3	2	1	...	4	3	2	1	...	...	..	...	...	...	...	...
G	...	...	...	...	1	...	...	...	1	1	1	1	...	...	...	...	...	...	...	...	...	...	...	...
Trace lost	...	...	...	...	...	...	...	...	...	...	...	2	4	1	...	...	...	...	...	...	3	...	...	11

Date.	July.				August.				September.				October.				November.				December.				Remarks.
1911	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	
1	S	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	S	S	S	S	
2	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	S	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	
3	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	
4	S	S	S	C	S	S	S	S	(C)	(C)	(C)	(C)	S	S	S	C	S	S	S	S	C	C	C	C	
5	C	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C	
6	C	C	—	C	S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	M	M	M	S	
7	S	S	S	C	C	C	C	C	S	S	S	S	S	C	C	C	C	C	C	C	S	S	S	S	
8	S	S	S	S	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	C	S	C	C	C	
9	C	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	C	C	C	C	
10	C	C	C	C	C	C	C	C	C	C	C	C	M	M	S	S	S	S	S	S	S	S	S	C	
11	S	S	S	C	C	C	C	C	S	S	S	S	M	M	M	S	C	C	C	C	G	G	G	G	
12	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
13	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	
14	(C)	(C)	(C)	(C)	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	M	M	M	S	S	S	S	S	
15	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	S	(C)	(C)	(C)	(C)	S	S	S	S	S	C	C	C	
16	C	C	C	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	
17	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	
18	S	S	S	S	C	C	C	C	S	S	S	S	M	M	M	S	C	C	C	C	S	S	S	S	
19	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)	
20	S	S	S	S	S	S	S	S	M	M	M	M	S	S	S	C	S	S	S	S	S	S	C	C	
21	(C)	(C)	(C)	(C)	S	S	S	S	M	M	M	M	S	S	C	C	C	C	C	C	C	C	C	C	
22	C	C	C	C	(C)	(C)	(C)	(C)	M	S	S	S	S	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	
23	(C)	(C)	(C)	(C)	M	M	M	M	S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	
24	S	S	S	S	M	M	M	M	(S)	(C)	(C)	(C)	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	
25	C	C	C	C	S	S	S	S	C	C	C	C	S	S	S	C	S	S	S	S	S	S	S	S	
26	C	C	C	C	S	S	S	S	C	C	C	C	S	S	C	C	S	S	S	S	S	S	S	S	
27	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	
28	S	S	S	S	S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	S	
29	S	S	S	S	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	
30	S	S	S	S	C	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	C	C	C	C	C	C	C	C	
31	C	C	C	C	S	S	S	S	...	...	...	...	C	C	C	C	...	...	...	...	S	S	S	S	
C	16	16	15	19	16	16	16	15	15	16	16	16	9	11	13	16	15	15	15	16	14	16	17	18	
S	15	15	15	12	13	13	13	14	12	12	12	12	19	17	16	15	14	14	14	14	15	13	12	12	
M	...	..	...	...	2	2	2	2	3	2	2	2	3	3	2	...	1	1	1	...	1	1	1	...	
G	...	...	...	...	...	...	...	...	...	...	...	...	...	.	...	...	...	..	...	...	1	1	1	1	
Trace lost	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	..	...	..	...	...	...	...	...	...	

(C)=The selected quiet day. C=Calm. S=Slight. M=Moderate. G=Great. — =Trace lost.

C.—Tables of results at Dehra Dūn.

Hourly Means of the Declination as determined at Dehra Dūn from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
E. 2°+													Winter.													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	30·8	30·6	30·6	30·2	29·9	29·7	29·7	29·7	30·0	31·1	31·9	31·4	30·5	30·2	30·3	30·1	30·4	30·5	30·6	30·6	30·8	30·7	30·8	30·8	30·9	30·5
February .	30·7	30·7	30·1	30·1	30·1	30·0	30·0	29·7	29·8	30·3	30·4	30·1	30·0	29·9	30·2	30·4	30·2	30·2	30·4	30·5	30·6	30·6	30·5	30·7	30·6	30·2
March .	30·1	30·1	30·1	30·0	29·9	29·8	29·7	29·9	31·3	32·3	32·7	32·2	30·7	29·4	29·0	29·5	30·0	30·1	30·1	30·1	30·0	30·0	30·0	30·0	30·0	30·3
October .	28·5	28·5	28·5	28·3	28·2	28·1	28·1	28·7	29·2	29·3	28·8	27·5	27·2	27·0	27·6	28·4	28·6	28·3	28·3	28·2	28·2	28·2	28·3	28·4	28·3	28·3
November .	28·1	28·1	28·1	27·9	27·7	27·7	27·7	28·0	28·5	28·4	27·9	27·3	27·0	27·4	28·1	28·3	28·2	28·1	28·2	28·1	28·0	28·1	28·2	28·1	28·1	28·0
December .	27·6	27·7	27·6	27·5	27·4	27·3	27·3	27·5	28·0	28·2	27·9	27·0	26·8	27·3	28·1	28·3	28·1	27·6	27·7	27·6	27·6	27·5	27·5	27·6	27·6	27·6
Means .	29·3	29·3	29·2	29·0	28·9	28·8	28·8	28·9	29·5	29·9	29·9	29·3	28·7	28·5	28·9	29·2	29·3	29·1	29·2	29·2	29·2	29·2	29·2	29·3	29·3	29·2
E. 2°+													Summer.													
April .	30·2	30·4	30·2	30·3	30·2	30·2	30·4	31·2	32·1	32·1	30·8	29·3	28·4	27·9	28·3	29·0	29·6	30·1	30·1	30·0	29·2	29·9	30·1	30·2	30·1	30·0
May .	29·9	29·9	30·0	30·0	30·1	30·1	31·0	31·9	32·1	31·1	29·7	28·1	27·0	26·6	27·2	28·2	29·0	29·4	29·7	29·4	29·3	29·4	29·6	29·7	29·8	29·5
June .	29·7	29·8	29·9	30·1	30·1	30·4	31·4	32·0	31·7	30·6	29·1	27·4	26·9	26·7	27·0	27·6	28·4	28·9	29·1	29·1	29·0	29·1	29·3	29·4	29·7	29·3
July .	29·4	29·6	29·6	29·6	29·7	29·7	30·5	31·3	31·3	30·7	29·6	28·0	27·9	26·6	26·7	27·3	27·9	28·5	28·8	28·6	28·5	28·6	28·7	29·0	29·3	29·0
August .	29·1	29·1	29·2	29·4	29·4	29·5	30·4	31·5	31·9	31·0	29·5	27·8	26·8	26·0	26·2	27·2	28·0	28·6	28·6	28·4	28·5	28·5	28·6	28·7	28·8	28·8
September .	28·5	28·5	28·6	28·5	28·5	28·5	29·0	30·1	30·9	30·7	29·1	27·5	26·4	25·9	26·1	27·2	28·2	28·6	28·5	28·3	28·2	28·3	28·4	28·4	28·6	28·4
Means	29·5	29·6	29·6	29·7	29·7	29·7	30·5	31·3	31·7	31·0	29·6	28·0	27·1	26·6	26·9	27·8	28·5	29·0	29·1	29·0	28·9	29·0	29·1	29·2	29·4	29·3

Diurnal Inequality of the Declination at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·3	+0·1	+0·1	−0·3	−0·6	−0·8	−0·8	−0·8	−0·5	+0·6	+1·4	+0·9	0	−0·3	−0·2	−0·4	−0·1	0	+0·1	+0·1	+0·3	+0·3	+0·3	+0·3	+0·4
February	+0·5	+0·5	−0·1	−0·1	−0·1	−0·2	−0·2	−0·5	−0·4	+0·1	+0·2	−0·1	−0·2	−0·3	0	+0·2	0	0	+0·2	+0·3	+0·4	+0·4	+0·3	+0·5	+0·4
March	−0·2	−0·2	−0·2	−0·3	−0·4	−0·5	−0·6	−0·4	+1·0	+2·0	+2·4	+1·9	+0·4	−0·9	−1·3	−0·8	−0·3	−0·2	−0·2	−0·2	−0·3	−0·3	−0·3	−0·3	−0·3
October	+0·2	+0·2	+0·2	0	−0·1	−0·2	−0·2	+0·4	+0·9	+1·0	+0·5	−0·8	−1·1	−1·3	−0·7	+0·1	+0·3	0	0	−0·1	−0·1	−0·1	0	+0·1	0
November	+0·1	+0·1	+0·1	−0·1	−0·3	−0·3	−0·3	0	+0·5	+0·4	−0·1	−0·7	−1·0	−0·6	+0·1	+0·3	+0·2	+0·1	+0·2	+0·1	0	+0·1	+0·2	+0·1	+0·1
December	0	+0·1	0	−0·1	−0·2	−0·3	−0·3	−0·1	+0·4	+0·6	+0·3	−0·6	−0·8	−0·3	+0·5	+0·7	+0·5	0	+0·1	0	0	−0·1	−0·1	0	0
Means	+0·1	+0·1	0	−0·2	−0·3	−0·4	−0·4	−0·3	+0·3	+0·7	+0·7	+0·1	−0·5	−0·7	−0·3	0	+0·1	−0·1	0	0	0	0	0	+0·1	+0·1
Summer.																									
April	+0·2	+0·4	+0·2	+0·3	+0·2	+0·2	+0·4	+1·2	+2·1	+2·1	+0·8	−0·7	−1·6	−2·1	−1·7	−1·0	−0·4	+0·1	+0·1	0	−0·1	−0·1	+0·1	+0·2	+0·1
May	+0·4	+0·4	+0·5	+0·5	+0·6	+0·6	+1·5	+2·4	+2·6	+1·6	+0·2	−1·4	−2·5	−2·9	−2·3	−1·3	−0·5	−0·1	+0·2	−0·1	−0·2	−0·1	+0·1	+0·2	+0·3
June	+0·4	+0·5	+0·6	+0·8	+0·8	+1·1	+2·1	+2·7	+2·4	+1·3	−0·2	−1·9	−2·4	−2·6	−2·3	−1·7	−0·9	−0·4	−0·2	−0·2	−0·3	−0·2	0	+0·1	+0·4
July	+0·4	+0·6	+0·6	+0·6	+0·7	+0·7	+1·5	+2·3	+2·3	+1·7	+0·6	−1·0	−1·8	−2·4	−2·3	−1·7	−1·1	−0·5	−0·2	−0·4	−0·5	−0·4	−0·3	0	+0·3
August	+0·3	+0·3	+0·4	+0·6	+0·6	+0·7	+1·6	+2·7	+3·1	+2·2	+0·7	−1·0	−2·0	−2·8	−2·6	−1·6	−0·8	−0·2	−0·2	−0·4	−0·3	−0·3	−0·2	−0·1	0
September	+0·1	+0·1	+0·2	+0·1	+0·1	+0·1	+0·6	+1·7	+2·5	+2·3	+0·7	−0·9	−2·0	−2·5	−2·3	−1·2	−0·2	+0·2	+0·1	−0·1	−0·2	−0·1	0	0	+0·2
Means	+0·3	+0·4	+0·4	+0·5	+0·5	+0·5	+1·3	+2·1	+2·5	+1·8	+0·4	−1·2	−2·1	−2·6	−2·3	−1·4	−0·7	−0·2	−0·1	−0·2	−0·3	−0·2	−0·1	0	+0·2

NOTE.—When the sign is + the magnet points to the East, and when — to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Dehra Dūn from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
·33000 C. G. S. +													Winter.													
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	238	235	233	236	236	238	238	241	245	250	244	239	241	214	242	242	242	241	240	239	236	238	238	242	239	240
February	239	230	232	234	234	234	237	240	246	252	255	256	255	248	239	236	235	233	232	230	232	230	231	228	236	238
March	210	239	240	240	241	242	243	247	251	255	260	262	262	258	254	249	241	243	243	239	238	238	238	239	241	246
October	236	226	228	231	230	231	230	230	228	227	229	235	239	241	238	234	230	227	226	224	223	223	223	226	226	229
November	228	229	229	228	228	230	231	231	232	235	236	241	244	241	235	231	228	226	227	227	226	226	227	229	231	231
December	223	219	221	220	221	223	224	225	222	219	218	221	225	226	221	220	220	221	222	221	222	223	223	225	228	222
Means	232	230	231	232	232	233	234	236	237	240	240	242	244	243	238	235	233	232	232	230	230	230	230	232	234	234
													Summer.													
April	237	234	237	237	236	238	237	238	236	240	245	251	253	255	254	249	244	241	238	236	236	237	236	237	236	241
May	243	243	242	241	240	242	242	237	235	239	242	246	253	256	252	250	246	241	239	239	239	242	245	243	247	243
June	243	245	243	242	240	244	244	246	245	245	250	256	260	263	264	256	246	240	239	241	242	242	243	244	245	247
July	240	240	244	242	211	241	242	238	233	233	235	244	251	254	254	254	249	242	240	238	240	242	243	243	243	243
August	239	242	240	236	237	237	238	237	233	231	234	239	247	251	251	250	245	241	240	241	241	243	243	244	246	241
September	235	235	236	235	234	235	237	233	227	224	226	232	238	244	245	244	240	236	235	235	233	235	234	235	236	235
Means	240	240	240	239	238	240	240	238	235	235	239	245	250	254	253	251	245	240	239	238	239	240	211	241	242	242

Diurnal Inequality of the Horizontal Force at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	−2	−5	−7	−4	−4	−2	−2	+1	+5	+10	+4	−1	+1	+4	+2	+2	+2	+4	0	−1	−4	−2	−2	+2	−1
February	+1	−8	−6	−4	−4	−4	−1	+2	+8	+14	+17	+18	+17	+10	+1	−2	−3	−5	−6	−8	−6	−8	−7	−10	−2
March	−6	−7	−6	−6	−5	−4	−3	+1	+5	+9	+14	+16	+16	+12	+8	+3	−2	−3	−3	−7	−8	−8	−8	−7	−5
October	−3	−3	−1	+2	+1	+2	+1	+1	−1	−2	0	+6	+10	+12	+9	+5	+1	−2	−3	−5	−6	−6	−6	−3	−3
November	−3	−2	−2	−3	−3	−1	0	0	+1	+4	+5	+10	+13	+10	+4	0	−3	−5	−4	−4	−5	−5	−4	−2	0
December	+1	−3	−1	−2	−1	+1	+2	+3	0	−3	−4	−1	+3	+4	−1	−2	−2	−1	0	−1	0	+1	+1	+3	+6
Means	−2	−4	−3	−2	−2	−1	0	+2	+3	+6	+6	+8	+10	+9	+4	+1	−1	−2	−2	−4	−4	−4	−4	−2	0
Summer.																									
April	−4	−7	−4	−4	−5	−3	−4	−3	−5	−1	+4	+10	+12	+14	+13	+8	+3	0	−3	−5	−5	−4	−5	−4	−5
May	0	0	−1	−2	−3	−1	−1	−6	−8	−4	−1	+3	+10	+13	+9	+7	+3	−2	−4	−4	−4	−1	+2	0	+4
June	−4	−2	−4	−5	−7	−3	−3	−1	−2	−2	+3	+9	+13	+16	+17	+9	−1	−7	−8	−6	−5	−5	−4	−3	−2
July	−3	−3	+1	−1	−2	−2	−1	−5	−10	−10	−8	+1	+8	+11	+11	+11	+6	−1	−3	−5	−3	−1	0	0	0
August	−2	+1	−1	−5	−4	−4	−3	−4	−8	−10	−7	−2	+6	+10	+10	+9	+4	0	−1	0	0	+2	+2	+3	+5
September	0	0	+1	0	−1	0	+2	−2	−8	−11	−9	−3	+3	+9	+10	+9	+5	+1	0	0	−2	0	−1	0	+1
Means	−2	−2	−2	−3	−4	−2	−2	−4	−7	−7	−3	+3	+8	+12	+11	+9	+3	−2	−3	−4	−3	−2	−1	−1	0

NOTE.—When the sign is + the H. F. is greater, and when — it is less than the mean

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Dehra Dūn from the selected quiet days in 1911.

·32000 C. G. S. +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	80	79	79	79	79	79	78	79	81	83	78	71	72	75	74	73	76	79	79	78	78	80	80	81	80	78
February	94	93	94	94	94	94	94	94	96	95	92	92	91	90	92	94	93	93	94	95	95	95	95	95	96	94
March	103	103	102	102	102	101	102	105	107	105	101	92	87	88	94	97	99	101	101	100	100	101	101	101	101	100
October	164	164	164	165	164	164	164	167	167	164	159	154	153	157	160	162	164	162	163	164	164	165	165	165	165	163
November	179	179	178	178	178	178	178	179	179	176	172	169	171	171	173	175	175	175	177	177	177	177	177	178	178	176
December	183	182	182	182	182	182	183	183	184	183	180	77	179	181	182	182	182	181	181	181	181	181	181	181	181	181
Means	134	133	133	133	133	133	133	135	136	134	130	125	126	127	129	131	132	132	133	133	133	133	133	134	134	132
Summer.																										
April	118	117	117	116	116	116	117	120	119	113	104	102	103	106	109	112	113	114	115	115	116	117	118	118	118	114
May	131	131	131	131	132	132	136	135	130	124	120	118	121	124	128	132	132	132	132	132	132	133	133	133	133	130
June	152	152	151	150	149	151	153	152	145	139	134	128	128	130	134	136	140	143	144	143	143	143	143	143	143	143
July	150	150	151	150	150	151	153	153	149	144	137	132	135	139	142	145	148	148	148	148	149	150	150	151	151	147
August	155	156	155	154	155	155	158	160	157	151	145	144	143	147	150	154	155	155	156	157	157	159	159	159	159	154
September	147	147	147	146	146	147	148	150	150	145	138	135	138	142	145	147	149	148	147	147	148	148	148	148	149	146
Means	142	142	142	141	141	142	144	145	142	136	130	127	128	131	135	138	140	140	140	140	141	142	142	142	142	139

Diurnal Inequality of the Vertical Force at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	+2	+1	+1	+1	+1	+1	0	+1	+3	+5	0	−7	−6	−3	−4	−5	−2	+1	+1	0	0	+2	+2	+3	+2
February	0	−1	0	0	0	0	0	0	+2	+1	−2	−2	−3	−4	−2	0	−1	−1	0	+1	+1	+1	+1	+1	+2
March	+3	+3	+2	+2	+2	+1	+2	+5	+7	+5	+1	−8	−13	−12	−6	−3	−1	+1	+1	0	0	+1	+1	+1	+1
October	+1	+1	+1	+2	+1	+1	+1	+4	+4	+1	−4	−9	−10	−6	−3	−1	+1	−1	0	+1	+1	+2	+2	+2	+2
November	+3	+3	+2	+2	+2	+2	+2	+3	+3	0	−4	−7	−5	−5	−3	−1	−1	−1	+1	+1	+1	+1	+1	+2	+2
December	+2	+1	+1	+1	+1	+1	+2	+2	+3	+2	−1	−4	−2	0	+1	+1	+1	0	0	0	0	0	0	0	0
Means	+2	+1	+1	+1	+1	+1	+1	+3	+4	+2	−2	−6	−6	−5	−3	−1	0	0	+1	+1	+1	+1	+1	+2	+2
Summer.																									
April	+4	+3	+3	+2	+2	+2	+3	+6	+5	−1	−10	−12	−11	−8	−5	−2	−1	0	+1	+1	+2	+3	+4	+4	+4
May	+1	+1	+1	+1	+2	+2	+6	+5	0	−6	−10	−12	−9	−6	−2	+2	+2	+2	+2	+2	+2	+3	+3	+3	+3
June	+9	+9	+8	+7	+6	+8	+10	+9	+2	−4	−9	−15	−15	−13	−9	−7	−3	0	+1	0	0	0	0	0	0
July	+3	+3	+4	+3	+3	+4	+6	+5	+2	−3	−10	−15	−12	−8	−5	−2	+1	+1	+1	+1	+2	+3	+3	+4	+4
August	+1	+2	+1	0	+1	+1	+4	+6	−3	−3	−9	−10	−11	−7	−4	0	+1	+1	+2	+3	+3	+5	+5	+5	+5
September	+1	+1	+1	0	0	+1	+2	+4	+4	−1	−8	−11	−8	−4	−1	+1	+3	+2	+1	+1	+2	+2	+2	+2	+3
Means	+3	+3	+3	+2	+2	+3	+5	+6	+3	−3	−9	−12	−11	−8	−4	−1	+1	+1	+1	+1	+2	+3	+3	+3	+3

NOTE.—When the sign is + the V. F. is greater, and when − it is less than the mean.

Hourly Means of the Dip as determined at Dehra Dūn from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
43° +												Winter.														
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	59·1	59·1	59·3	59·1	59·1	59·0	59·0	58·9	58·8	58·6	58·7	58·5	58·5	58·5	58·5	58·5	58·6	58·7	58·9	58·9	59·1	59·1	59·1	58·9	59·0	58·9
February .	59·7	60·2	60·1	60·0	60·0	60·0	59·9	59·7	59·5	59·1	58·8	58·8	58·8	59·1	59·7	59·9	59·9	60·0	60·1	60·3	60·2	60·3	60·3	60·4	60·0	59·8
March .	60·2	60·3	60·1	60·1	60·1	60·0	60·0	59·9	59·9	59·5	59·1	58·5	58·2	58·4	59·0	59·4	59·8	59·9	59·9	60·1	60·2	60·2	60·2	60·1	60·1	59·7
October .	64·2	64·2	64·1	64·0	64·0	63·9	64·0	64·1	64·3	64·1	63·7	63·2	62·9	63·1	63·4	63·7	64·0	64·0	64·1	64·3	64·3	64·4	64·4	64·2	64·2	63·9
November .	64·9	64·8	64·8	64·8	64·8	64·7	64·7	64·7	64·6	64·3	64·1	63·7	63·6	63·8	64·2	64·5	64·7	64·8	64·8	64·8	64·9	64·9	64·8	64·8	64·7	64·6
December .	65·4	65·5	65·4	65·4	65·4	65·3	65·3	65·2	65·4	65·6	65·5	65·2	65·0	65·1	65·4	65·4	65·4	65·4	65·3	65·4	65·3	65·2	65·2	65·1	65·0	65·3
Means .	62·3	62·4	62·3	62·2	62·2	62·2	62·2	62·1	62·1	61·9	61·7	61·3	61·2	61·3	61·7	61·9	62·1	62·1	62·2	62·3	62·3	62·4	62·3	62·3	62·2	62·0
												Summer.														
April .	61·2	61·3	61·1	61·0	61·1	61·0	61·1	61·2	61·2	60·7	60·0	59·6	59·5	59·6	59·8	60·2	60·5	60·7	61·0	61·0	61·1	61·1	61·2	61·2	61·2	60·7
May .	61·5	61·5	61·6	61·6	61·8	61·6	61·8	62·1	61·9	61·4	61·0	60·7	60·5	60·5	60·9	61·2	61·4	61·7	61·8	61·8	61·8	61·7	61·5	61·6	61·4	61·4
June .	62·7	62·6	62·6	62·6	62·7	62·6	62·7	62·5	62·2	61·8	61·3	60·7	60·5	60·5	60·6	61·1	61·9	62·4	62·4	62·3	62·2	62·2	62·2	62·2	62·1	62·0
July .	62·7	62·7	62·6	62·6	62·7	62·7	62·7	62·9	63·0	62·7	62·3	61·6	61·4	61·4	61·6	61·7	62·1	62·5	62·6	62·7	62·7	62·6	62·6	62·6	62·6	62·4
August .	63·0	62·9	63·0	63·1	63·1	63·1	63·3	63·4	63·5	63·2	62·7	62·4	62·0	62·0	62·2	62·4	62·7	62·9	63·0	63·1	63·1	63·0	63·0	63·0	62·9	62·9
September .	62·8	62·8	62·7	62·7	62·8	62·8	62·7	63·1	63·4	63·3	62·8	62·3	62·2	62·1	62·2	62·4	62·7	62·8	62·8	62·8	62·9	62·8	62·9	62·8	62·9	62·7
Means .	62·3	62·3	62·3	62·3	62·4	62·3	62·4	62·5	62·5	62·2	61·7	61·2	61·0	61·0	61·2	61·5	61·9	62·2	62·3	62·3	62·3	62·2	62·2	62·2	62·2	62·0

Diurnal Inequality of the Dip at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	′	′	′	′	′	′	′	′	′	′	′		′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·2	+0·2	+0·4	+0·2	+0·2	+0·1	+0·1	0	−0·1	−0·3	−0·2	−0·4	−0·4	−0·4	−0·4	−0·4	−0·3	−0·2	0	0	+0·2	+0·2	+0·2	0	+0·1
February	−0·1	+0·4	+0·3	+0·2	+0·2	+0·2	+0·1	−0·1	−0·3	−0·7	−1·0	−1·0	−1·0	−0·7	−0·1	+0·1	+0·1	+0·2	+0·3	+0·5	+0·4	+0·5	+0·5	+0·6	+0·2
March	+0·5	+0·6	+0·4	+0·4	+0·4	+0·3	+0·3	+0·2	+0·2	−0·2	−0·6	−1·2	−1·5	−1·3	−0·7	−0·3	+0·1	+0·2	+0·2	+0·4	+0·5	+0·5	+0·5	+0·4	+0·4
October	+0·3	+0·3	+0·2	+0·1	+0·1	0	+0·1	+0·2	+0·4	+0·2	−0·2	−0·7	−1·0	−0·8	−0·5	−0·2	+0·1	+0·1	+0·2	+0·4	+0·4	+0·5	+0·5	+0·3	+0·3
November	+0·3	+0·2	+0·2	+0·2	+0·2	+0·1	+0·1	+0·1	0	−0·3	−0·5	−0·9	−1·0	−0·8	−0·4	−0·1	+0·1	+0·2	+0·2	+0·2	+0·3	+0·3	+0·2	+0·2	+0·1
December	+0·1	+0·2	+0·1	+0·1	+0·1	0	0	−0·1	+0·1	+0·3	+0·2	−0·1	−0·3	−0·2	+0·1	+0·1	+0·1	+0·1	0	+0·1	0	−0·1	−0·1	−0·2	−0·3
Means	+0·3	+0·4	+0·3	+0·2	+0·2	+0·2	+0·2	+0·1	+0·1	−0·1	−0·3	−0·7	−0·8	−0·7	−0·3	−0·1	+0·1	+0·1	+0·2	+0·3	+0·3	+0·4	+0·3	+0·3	+0·2
Summer.																									
April	+0·5	+0·6	+0·4	+0·3	+0·4	+0·3	+0·4	+0·5	+0·5	0	−0·7	−1·1	−1·2	−1·1	−0·9	−0·5	−0·2	0	+0·3	+0·3	+0·4	+0·4	+0·5	+0·5	+0·5
May	+0·1	+0·1	+0·2	+0·2	+0·4	+0·2	+0·4	+0·7	+0·5	0	−0·4	−0·7	−0·9	−0·9	−0·5	−0·2	0	+0·3	+0·4	+0·4	+0·4	+0·3	+0·1	+0·2	0
June	+0·7	+0·6	+0·6	+0·6	+0·7	+0·6	+0·7	+0·5	+0·2	−0·2	−0·7	−1·3	−1·6	−1·5	−1·4	−0·9	−0·1	+0·4	+0·4	+0·3	+0·2	+0·2	+0·2	+0·2	+0·1
July	+0·3	+0·3	+0·2	+0·2	+0·3	+0·3	+0·3	+0·5	+0·6	+0·3	−0·1	−0·8	−1·0	−1·0	−0·8	−0·7	−0·3	+0·1	+0·2	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2
August	+0·1	0	+0·1	+0·2	+0·2	+0·2	+0·4	+0·5	+0·6	+0·3	−0·2	−0·5	−0·9	−0·9	−0·7	−0·5	−0·2	0	+0·1	+0·2	+0·2	+0·1	+0·1	+0·1	0
September	+0·1	+0·1	0	0	+0·1	+0·1	0	+0·4	+0·7	+0·6	+0·1	−0·4	−0·5	−0·6	−0·5	−0·3	0	+0·1	+0·1	+0·1	+0·2	+0·1	+0·2	+0·1	+0·2
Means	+0·3	+0·3	+0·3	+0·3	+0·4	+0·3	+0·4	+0·5	+0·5	+0·2	−0·3	−0·8	−1·0	−1·0	−0·8	−0·5	−0·1	+0·2	+0·3	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2

NOTE.—When the sign is + the Dip is more, and when − it is less than the mean.

D.—*Tables of results at Barrackpore.*

Hourly Means of the Declination as determined at Barrackpore from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
E. 0°+													Winter.													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	52·5	52·4	52·2	52·2	52·0	51·7	51·5	51·2	51·7	52·9	53·7	53·2	52·3	52·3	52·2	51·9	52·4	52·6	52·6	52·7	52·6	52·8	52·5	52·6	52·6	52·3
February	51·9	52·1	52·0	51·7	51·7	51·6	51·5	51·2	51·4	52·2	52·6	52·3	52·2	52·1	52·0	52·1	52·3	52·3	52·1	52·1	52·2	52·1	52·2	52·1	52·1	52·0
March	51·4	51·3	51·3	51·2	51·1	50·9	50·9	51·4	52·7	53·8	54·2	53·6	52·3	51·2	50·9	51·1	51·4	51·7	51·6	51·4	51·2	51·2	51·2	51·2	51·3	51·7
October	48·4	48·4	48·3	48·2	48·0	48·0	48·0	48·7	49·2	49·3	48·3	47·5	47·3	47·6	47·8	48·4	48·6	48·5	48·2	48·2	48·1	48·1	48·2	48·3	48·3	48·2
November	47·9	47·9	47·8	47·7	47·6	47·5	47·6	47·8	48·0	48·1	47·7	47·2	47·2	47·5	47·9	48·3	48·2	47·9	48·1	48·0	47·9	47·7	47·8	47·9	47·9	47·8
December	47·5	47·5	47·4	47·3	47·1	47·0	47·0	47·3	47·9	48·1	47·4	46·5	46·5	46·9	47·6	47·9	47·7	47·4	47·5	47·5	47·4	47·3	47·3	47·4	47·4	47·3
Means	49·9	49·9	49·8	49·7	49·6	49·5	49·4	49·6	50·2	50·7	50·7	50·1	49·6	49·6	49·7	50·0	50·1	50·1	50·0	50·0	49·9	49·9	49·9	49·9	49·9	49·9
													Summer.													
April	51·3	51·1	51·4	51·3	51·3	51·2	51·5	52·6	53·0	52·9	51·9	50·6	50·0	49·5	49·6	50·3	51·0	51·4	51·3	51·0	50·9	51·1	51·1	51·2	51·3	51·2
May	50·9	50·9	50·9	51·0	51·0	51·1	52·0	53·2	53·1	52·2	50·7	49·5	48·5	48·6	49·1	49·8	50·4	50·8	50·8	50·6	50·4	50·3	50·4	50·6	50·8	50·7
June	50·2	50·4	50·4	50·5	50·6	50·8	51·7	52·7	52·4	51·4	50·1	48·3	47·6	47·1	47·5	48·3	49·3	50·3	50·2	49·8	49·8	49·8	50·0	50·1	50·2	50·0
July	50·0	50·2	50·3	50·1	50·3	50·4	51·1	51·9	51·8	50·9	49·7	48·7	47·8	47·6	47·9	48·3	49·1	49·5	49·7	49·4	49·3	49·2	49·4	49·5	49·9	49·7
August	49·6	49·6	49·6	49·7	49·8	49·9	50·7	52·3	52·4	51·4	49·8	48·2	47·3	47·0	47·4	48·0	48·8	49·2	49·2	49·0	49·1	49·0	49·2	49·3	49·5	49·4
September	48·9	49·0	49·0	49·0	49·0	48·9	49·5	50·9	51·5	51·0	49·4	47·7	46·9	46·7	47·1	48·2	49·1	49·4	49·0	48·8	48·6	48·7	48·7	48·8	48·9	48·9
Means	50·2	50·3	50·3	50·3	50·3	50·4	51·1	52·3	52·4	51·6	50·3	48·8	48·0	47·8	48·1	48·8	49·6	50·1	50·0	49·8	49·7	49·7	49·8	49·9	50·1	50·0

Diurnal Inequality of the Declination at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	+0·2	+0·1	−0·1	−0·1	−0·3	−0·6	−0·8	−1·1	−0·6	+0·6	+1·4	+0·9	0	0	−0·1	−0·4	+0·1	+0·3	+0·3	+0·4	+0·3	+0·5	+0·2	+0·3	+0·3
February . .	−0·1	+0·1	0	−0·3	−0·3	−0·4	−0·5	−0·8	−0·6	+0·2	+0·6	+0·3	+0·2	+0·1	0	+0·1	+0·3	+0·3	+0·1	+0·1	+0·2	+0·1	+0·2	+0·1	+0·1
March . .	−0·3	−0·4	−0·4	−0·5	−0·6	−0·8	−0·8	−0·3	+1·0	+2·1	+2·5	+1·9	+0·6	−0·5	−0·8	−0·6	−0·3	0	−0·1	−0·3	−0·5	−0·5	−0·5	−0·5	−0·4
October . .	+0·2	+0·2	+0·1	0	−0·2	−0·2	−0·2	+0·5	+1·0	+1·1	+0·1	−0·7	−0·9	−0·6	−0·4	+0·2	+0·4	+0·3	0	0	−0·1	−0·1	0	+0·1	+0·1
November . .	+0·1	+0·1	0	−0·1	−0·2	−0·3	−0·2	0	+0·2	+0·3	−0·1	−0·6	−0·6	−0·3	+0·1	+0·5	+0·4	+0·1	+0·3	+0·2	+0·1	−0·1	0	+0·1	+0·1
December . .	+0·2	+0·2	+0·1	0	−0·2	−0·3	−0·3	0	+0·6	+0·8	+0·1	−0·8	−0·8	−0·4	+0·3	+0·6	+0·4	+0·1	+0·2	+0·2	+0·1	0	0	+0·1	+0·1
Means . .	0	0	−0·1	−0·2	−0·3	−0·4	−0·5	−0·3	+0·3	+0·8	+0·8	+0·2	−0·3	−0·3	−0·2	+0·1	+0·2	+0·2	+0·1	+0·1	0	0	0	0	0
Summer.																									
April . .	+0·1	+0·2	+0·2	+0·1	+0·1	0	+0·3	+1·4	+1·8	+1·7	+0·7	−0·6	−1·2	−1·7	−1·6	−0·9	−0·2	+0·2	+0·1	−0·2	−0·3	−0·1	−0·1	0	+0·1
May . .	+0·2	+0·2	+0·2	+0·3	+0·3	+0·4	+1·3	+2·5	+2·4	+1·5	0	−1·2	−2·2	−2·1	−1·6	−0·9	−0·3	+0·1	+0·1	−0·1	−0·3	−0·4	−0·3	−0·1	+0·1
June . .	+0·2	+0·4	+0·4	+0·5	+0·6	+0·8	+1·7	+2·7	+2·4	+1·4	+0·1	−1·7	−2·4	−2·9	−2·5	−1·7	−0·7	+0·3	+0·2	−0·2	0·2	−0·2	0	+0·1	+0·2
July . .	+0·3	+0·5	+0·6	+0·4	+0·6	+0·7	+1·4	+2·2	+2·1	+1·2	0	−1·0	−1·9	−2·1	−1·8	−1·4	−0·6	−0·2	0	−0·3	−0·4	−0·5	−0·3	−0·2	+0·2
August . .	+0·2	+0·2	+0·2	+0·3	+0·4	+0·5	+1·3	+2·9	+3·0	+2·0	+0·4	−1·2	−2·1	−2·4	−2·0	−1·4	−0·6	−0·2	−0·2	−0·4	−0·3	−0·4	−0·2	−0·1	+0·1
September . .	0	+0·1	+0·1	+0·1	+0·1	0	+0·6	+2·0	+2·6	+2·1	+0·5	−1·2	−2·0	−2·2	−1·3	−0·7	+0·2	+0·5	+0·1	−0·1	−0·3	−0·2	−0·2	−0·1	0
Means . .	+0·2	+0·3	+0·3	+0·3	+0·3	+0·4	+1·1	+2·3	+2·4	+1·6	+0·3	−1·2	−2·0	−2·2	−1·9	−1·2	−0·4	+0·1	0	−0·2	−0·3	−0·3	−0·2	−0·1	+0·1

NOTE.—When the sign is + the magnet points to the East, and when − to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Barrackpore from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
·37000 C. G. S. +													Winter.													
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		γ		γ	γ	γ	γ	γ	γ	γ	γ
January .	318	314	312	312	314	314	317	321	325	330	332	334	332	332	328	327	325	322	322	319	319	315	315	314	320	321
February .	325	322	317	318	322	322	322	327	333	342	346	349	348	344	335	326	324	321	321	318	317	315	320	315	319	327
March .	327	328	329	329	331	332	333	337	344	351	359	367	368	360	351	344	338	334	335	332	329	328	328	328	330	339
October .	329	329	329	331	334	335	336	333	334	339	346	351	353	348	343	339	335	332	330	328	326	325	325	328	324	335
November .	339	340	342	342	341	343	344	347	350	355	362	365	365	363	355	348	344	340	339	338	338	337	337	338	341	346
December .	345	348	347	347	347	349	351	353	352	352	354	362	363	359	356	350	350	347	349	348	347	348	349	349	350	351
Means .	331	330	329	330	332	333	334	336	340	345	350	355	355	351	345	339	336	333	333	331	329	328	329	329	331	337
													Summer.													
April .	324	326	325	327	329	329	330	330	333	343	355	361	360	356	351	346	340	336	332	328	326	325	327	326	327	336
May .	329	331	330	331	329	330	330	330	331	336	347	350	351	352	346	338	334	330	329	328	328	330	331	333	334	335
June .	333	333	334	333	333	332	336	342	345	351	353	363	368	370	364	355	341	332	329	330	330	331	331	331	334	342
July .	330	330	329	333	333	332	332	335	333	334	345	351	357	357	352	348	341	335	332	331	329	330	331	333	333	337
August .	331	331	334	332	329	331	332	332	330	333	338	344	349	349	346	344	342	338	336	335	335	334	335	335	337	336
September .	329	330	332	332	332	332	334	333	329	330	335	340	344	345	344	340	337	334	331	331	331	329	331	331	332	334
Means .	329	330	331	331	331	331	332	334	334	338	346	352	355	355	351	345	339	334	332	331	330	330	331	332	333	337

Diurnal Inequality of the Horizontal Force at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
													Winter.												
1911 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	−3	−7	−9	−9	−7	−7	−4	0	+4	+9	+11	+13	+11	+11	+7	+6	+4	+1	+1	−2	−2	−6	−6	−7	−1
February . .	−2	−5	−10	−9	−5	−5	−5	0	+6	+15	+19	+22	+21	+17	+8	−1	−3	−6	−6	−9	−10	−12	−7	−12	−8
March . . .	−12	−11	−10	−10	−8	−7	−6	−2	+5	+12	+20	+28	+29	+21	+12	+5	−1	−5	−4	−7	−10	−11	−11	−11	−9
October . .	−6	−6	−6	−4	−1	0	+1	−2	−1	+4	+11	+16	+18	+13	+8	+4	0	−3	−5	−7	−9	−10	−10	−7	−11
November . .	−7	−6	−4	−4	−5	−3	−2	+1	+4	+9	+16	+19	+19	+17	+9	+2	−2	−6	−7	−8	−8	−9	−9	−8	−5
December . .	−6	−3	−4	−4	−4	−2	0	+2	+1	+1	+3	+11	+12	+8	+5	−1	−1	−4	−2	−3	−4	−3	−2	−2	−1
Means .	−6	−7	−8	−7	−5	−4	−3	−1	+3	+8	+13	+18	+18	+14	+8	+2	−1	−4	−4	−6	−8	−9	−8	−8	−6
													Summer.												
April . . .	−12	−10	−11	−9	−7	−7	−6	−6	−3	+7	+19	+25	+24	+20	+15	+10	+4	0	−4	−8	−10	−11	−9	−10	−9
May . . .	−6	−4	−5	−4	−6	−5	−5	−5	−4	+1	+12	+15	+16	+17	+11	+3	−1	−5	−6	−7	−7	−5	−4	−2	−1
June . . .	−9	−9	−8	−9	−9	−10	−6	0	+3	+9	+11	+21	+26	+28	+22	+13	−1	−10	−13	−12	−12	−11	−11	−11	−8
July . .	−7	−7	−8	−4	−4	−5	−5	−2	−4	−3	+8	+14	+20	+20	+15	+11	+4	−2	−5	−6	−8	−7	−6	−4	−4
August . .	−5	−5	−2	−4	−7	−5	−4	−4	−6	−3	+2	+8	+13	+13	+10	+8	+6	+2	0	−1	−1	−2	−1	−1	+1
September . .	−5	−4	−2	−2	−2	−2	0	−1	−5	−4	+1	+6	+10	+11	+10	+6	+3	0	−3	−3	−3	−5	−3	−3	−2
Means .	−8	−7	−6	−6	−6	−6	−5	−3	−3	+1	+9	+15	+18	+18	+14	+8	+2	−3	−5	−6	−7	−7	−6	−5	−4

NOTE.—When the sign is + the H. F. is greater, and when — it is less than the mean value.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Barrackpore from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter. ·22000 C. G. S.+																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	177	177	177	177	177	178	178	179	181	179	174	168	168	171	170	171	174	176	177	176	176	176	177	176	177	175
February	185	184	185	185	185	186	186	187	189	189	187	186	186	186	184	182	183	184	185	184	185	185	185	184	186	185
March	201	201	201	202	202	202	203	204	202	198	194	190	187	189	194	196	198	200	201	202	203	203	204	204	204	199
October	250	250	250	251	251	251	251	253	251	247	244	241	240	241	244	244	245	246	248	248	248	248	249	249	248	247
November	257	257	257	257	256	257	257	256	254	251	248	248	249	251	251	252	254	254	254	254	255	254	254	253	253	254
December	261	261	261	261	262	262	262	263	260	257	253	253	256	258	259	260	261	262	263	262	261	260	260	260	260	260
Means	222	222	222	222	222	223	223	224	223	220	217	214	214	216	217	218	219	220	221	221	221	221	222	221	221	220
Summer.																										
April	209	209	209	209	209	210	210	210	207	203	201	199	200	199	200	202	203	202	203	204	205	205	206	206	207	205
May	206	206	205	205	206	207	209	205	202	199	196	196	197	199	200	200	201	200	201	203	204	205	206	205	206	208
June	216	216	217	216	218	218	220	221	218	216	215	216	216	219	217	216	215	218	218	218	218	219	219	219	218	217
July	223	223	223	223	223	224	225	223	219	217	214	213	213	214	215	217	217	220	221	222	222	224	224	225	225	220
August	233	232	233	232	233	234	236	234	233	230	227	224	225	226	226	227	227	227	227	230	231	231	232	232	232	230
September	243	243	243	242	243	244	245	245	243	238	233	232	235	236	239	240	239	239	239	240	240	241	242	242	242	240
Means	222	222	222	221	222	223	224	223	220	217	214	213	214	216	216	217	217	218	218	220	220	221	222	222	222	219

Diurnal Inequality of the Vertical Force at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	+2	+2	+2	+2	+2	+3	+3	+4	+6	+4	−1	−7	−7	−4	−5	−4	−1	+1	+2	+1	+1	+1	+2	+1	+2
February	0	−1	0	0	0	+1	+1	+2	+4	+4	+2	+1	+1	+1	−1	−3	−2	−1	0	−1	0	0	0	−1	+1
March	+2	+2	+2	+3	+3	+3	+3	+5	+3	−1	−5	−9	−12	−10	−5	−3	−1	+1	+2	+3	+4	+4	+5	+5	+5
October	+3	+3	+3	+4	+4	+4	+4	+6	+4	0	−3	−6	−7	−6	−3	−3	−2	−1	+1	+1	+1	+1	+2	+2	+1
November	+3	+3	+3	+3	+2	+3	+3	+2	0	−3	−6	−6	−5	−3	−3	−2	0	0	0	0	+1	0	0	−1	−1
December	+1	+1	+1	+1	+2	+2	+2	+3	0	−3	−7	−7	−4	−2	−1	0	+1	+2	+3	+2	+1	0	0	0	0
Means	+2	+2	+2	+2	+2	+3	+3	+4	+3	0	−3	−6	−6	−4	−3	−2	−1	0	+1	+1	+1	+1	+2	+1	+1
Summer.																									
April	+4	+4	+4	+4	+4	+5	+5	+5	+2	−2	−4	−6	−5	−6	−5	−3	−2	−3	−2	−1	0	0	+1	+1	+2
May	+3	+3	+2	+2	+3	+4	+6	+2	−1	−4	−7	−7	−6	−4	−3	−3	−2	−3	−2	0	+1	+2	+3	+2	+3
June	−1	−1	0	−1	+1	+1	+3	+4	+1	−1	−2	−1	−1	+2	0	−1	−2	+1	+1	+1	+1	+2	+2	+2	+1
July	+3	+3	+3	+3	+3	+4	+5	+3	−1	−3	−6	−7	−7	−6	−5	−3	−3	0	+1	+2	+2	+4	+4	+5	+5
August	+3	+2	+3	+2	+3	+4	+6	+4	+3	0	−3	−6	−5	−4	−4	−3	−3	−3	−3	0	+1	+1	+2	+2	+2
September	+3	+3	+3	+2	+3	+4	+5	+5	+3	−2	−7	−8	−5	−4	−1	0	−1	−1	−1	0	0	+1	+2	+2	+2
Means	+3	+3	+3	+2	+3	+4	+5	+4	+1	−2	−5	−6	−5	−3	−3	−2	−2	−1	−1	+1	+1	+2	+3	+3	+3

NOTE.—When the sign is + the V. F. is more, and when − it is less than the mean.

Hourly Means of the Dip as determined at Barrackpore from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
													Winter.													
				30° +																						
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′		′	′	′	′	′	′	′	′	′
January	43·3	43·5	43·5	43·5	43·5	43·5	43·4	43·3	43·3	43·0	42·5	42·1	42·2	42·4	42·5	42·6	42·8	43·1	43·2	43·2	43·2	43·4	43·4	43·4	43·2	43·1
February	43·6	43·6	43·9	43·9	43·7	43·8	43·8	43·6	43·5	43·2	42·9	42·7	42·7	42·9	43·1	43·3	43·5	43·7	43·8	43·8	43·9	44·0	43·8	43·9	43·9	43·5
March	44·6	44·6	44·5	44·6	44·5	44·4	44·4	44·4	44·0	43·4	42·8	42·2	42·0	42·4	43·2	43·5	43·9	44·2	44·2	44·4	44·6	44·7	44·8	44·8	44·7	44·0
October	47·8	47·8	47·8	47·8	47·7	47·6	47·6	47·9	47·7	47·2	46·7	46·3	46·2	46·4	46·8	47·0	47·2	47·4	47·6	47·8	47·8	47·9	47·9	47·8	47·9	47·4
November	47·9	47·9	47·8	47·8	47·8	47·8	47·7	47·5	47·3	46·8	46·4	46·2	46·3	46·5	46·8	47·2	47·5	47·7	47·7	47·8	47·8	47·8	47·8	47·7	47·5	47·4
December	47·9	47·8	47·8	47·8	47·9	47·8	47·8	47·7	47·6	47·4	47·0	46·7	46·9	47·2	47·4	47·7	47·7	47·9	47·9	47·9	47·8	47·8	47·7	47·7	47·7	47·6
Means	45·9	45·9	45·9	45·9	45·9	45·8	45·8	45·7	45·6	45·2	44·7	44·4	44·4	44·6	45·0	45·2	45·4	45·7	45·7	45·8	45·9	45·9	45·9	45·9	45·8	45·5
													Summer.													
April	45·2	45·2	45·2	45·1	45·0	45·1	45·1	45·1	44·8	44·1	43·4	43·1	43·2	43·3	43·5	43·9	44·2	44·3	44·5	44·8	44·9	44·9	44·9	45·0	45·0	44·5
May	44·8	44·8	44·7	44·7	44·8	44·9	45·0	44·7	44·5	44·1	43·4	43·3	43·3	43·4	43·8	44·1	44·3	44·4	44·5	44·7	44·8	44·7	44·8	44·6	44·7	44·4
June	45·4	45·4	45·4	45·4	45·5	45·6	45·5	45·3	45·0	44·7	44·5	44·2	44·0	44·1	44·2	44·5	45·0	45·6	45·7	45·6	45·6	45·6	45·6	45·6	45·5	45·1
July	45·9	45·9	46·0	45·8	45·8	45·9	46·0	45·7	45·6	45·4	44·8	44·4	44·2	44·3	44·6	44·8	45·1	45·5	45·7	45·8	45·9	46·0	46·0	46·0	46·0	45·5
August	46·6	46·5	46·5	46·5	46·7	46·7	46·8	46·6	46·6	46·3	45·9	45·5	45·3	45·4	45·5	45·7	45·7	45·9	46·0	46·2	46·3	46·4	46·4	46·4	46·3	46·2
September	47·3	47·3	47·2	47·2	47·2	47·3	47·3	47·3	47·3	47·0	46·4	46·2	46·2	46·3	46·5	46·7	46·8	46·9	47·0	47·1	47·1	47·2	47·2	47·2	47·2	47·0
Means	45·9	45·9	45·8	45·8	45·8	45·9	46·0	45·8	45·6	45·3	44·7	44·5	44·4	44·5	44·7	45·0	45·2	45·4	45·6	45·7	45·8	45·8	45·8	45·8	45·8	45·4

Diurnal Inequality of the Dip at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	+0·2	+0·4	+0·4	+0·4	+0·4	+0·4	+0·3	+0·2	+0·2	−0·1	−0·6	−1·0	−0·9	−0·7	−0·6	−0·5	−0·3	0	+0·1	+0·1	+0·1	+0·3	+0·3	+0·3	+0·1
February . .	+0·1	+0·1	+0·4	+0·4	+0·2	+0·3	+0·3	+0·1	0	−0·3	−0·6	−0·8	−0·8	−0·6	−0·4	−0·2	0	+0·2	+0·3	+0·3	+0·4	+0·5	+0·3	+0·4	+0·4
March . . .	+0·6	+0·6	+0·5	+0·6	+0·5	+0·4	+0·4	+0·4	0	−0·6	−1·2	−1·8	−2·0	−1·6	−0·8	−0·5	−0·1	+0·2	+0·2	+0·4	+0·6	+0·7	+0·8	+0·8	+0·7
October . .	+0·4	+0·4	+0·4	+0·4	+0·3	+0·2	+0·2	+0·5	+0·3	−0·2	−0·7	−1·1	−1·2	−1·0	−0·6	−0·1	−0·2	0	+0·2	+0·4	+0·4	+0·5	+0·5	+0·4	+0·5
November . .	+0·5	+0·5	+0·4	+0·4	+0·4	+0·4	+0·3	+0·1	−0·1	−0·6	−1·0	−1·2	−1·1	−0·9	−0·6	−0·2	+0·1	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4	+0·3	+0·1
December . .	+0·3	+0·2	+0·2	+0·2	+0·3	+0·2	+0·2	+0·1	0	−0·2	−0·6	−0·9	−0·7	−0·4	−0·2	−0·1	+0·1	+0·3	+0·3	+0·3	+0·2	+0·2	+0·1	+0·1	+0·1
Means .	+0·4	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3	+0·2	+0·1	−0·3	−0·8	−1·1	−1·1	−0·9	−0·5	−0·3	−0·1	+0·2	+0·2	+0·3	+0·4	+0·4	+0·4	+0·4	+0·3
Summer.																									
April . . .	+0·7	+0·7	+0·7	+0·6	+0·5	+0·6	+0·6	+0·6	+0·3	−0·4	−1·1	−1·4	−1·3	−1·2	−1·0	−0·6	−0·3	−0·2	0	+0·3	+0·4	+0·4	+0·4	+0·5	+0·5
May . . .	+0·4	+0·4	+0·3	+0·3	+0·4	+0·5	+0·6	+0·3	+0·1	−0·3	−1·0	−1·1	−1·1	−1·0	−0·6	−0·3	−0·1	0	+0·1	+0·3	+0·4	+0·3	+0·4	+0·2	+0·3
June . . .	+0·3	+0·3	+0·3	+0·3	+0·4	+0·5	+0·4	+0·2	−0·1	−0·4	−0·8	−0·9	−1·1	−1·0	−0·9	−0·6	−0·1	+0·5	+0·6	+0·5	+0·5	+0·5	+0·5	+0·5	+0·4
July . . .	+0·4	+0·4	+0·5	+0·3	+0·3	+0·4	+0·5	+0·2	+0·1	−0·1	−0·7	−1·1	−1·3	−1·2	−0·9	−0·7	−0·4	0	+0·2	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5
August . .	+0·4	+0·3	+0·3	+0·3	+0·5	+0·5	+0·6	+0·4	+0·4	+0·1	−0·3	−0·7	−0·9	−0·8	−0·7	−0·5	−0·5	−0·3	−0·2	0	+0·1	+0·2	+0·2	+0·2	+0·1
September . .	+0·3	+0·3	+0·2	+0·2	+0·2	+0·3	+0·3	+0·3	+0·3	0	−0·6	−0·8	−0·8	−0·7	−0·5	−0·3	−0·2	−0·1	0	+0·1	+0·1	+0·2	+0·2	+0·2	+0·3
Means .	+0·5	+0·5	+0·4	+0·4	+0·4	+0·5	+0·6	+0·4	+0·2	−0·1	−0·7	−0·9	−1·0	−0·9	−0·7	−0·4	−0·2	0	+0·2	+0·3	+0·4	+0·4	+0·4	+0·4	+0·4

NOTE.—When the sign is + the Dip is more, and when − it is less than the mean.

E.—Tables of results at Toungoo.

Hourly Means of the Declination as determined at Toungoo from the selected quiet days in 1911.

E. 0° +

Winter.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	22·0	21·8	21·7	21·6	21·5	21·2	20·9	20·8	21·0	22·0	22·7	22·4	21·9	22·0	21·8	21·6	21·7	22·0	22·0	22·0	22·0	22·0	22·0	21·9	21·9	21·8
February .	21·4	21·3	21·4	21·2	21·1	21·1	20·9	20·7	20·8	21·2	21·7	21·7	21·6	21·4	21·3	21·3	21·5	21·6	21·5	21·5	21·6	21·4	21·5	21·4	21·5	21·3
March .	21·0	20·9	21·0	20·8	20·6	20·4	20·3	20·9	21·8	22·8	23·0	22·8	21·9	21·0	20·4	20·6	21·0	21·1	21·0	21·1	21·0	20·8	20·8	20·8	20·8	21·1
October .	17·7	17·7	17·7	17·5	17·4	17·3	17·5	18·0	18·5	18·4	17·8	16·9	16·8	17·1	17·1	17·7	17·9	17·8	17·5	17·6	17·5	17·4	17·4	17·5	17·6	17·6
November .	17·1	17·1	17·0	17·0	16·9	16·7	16·7	16·9	17·0	16·9	16·8	16·4	16·4	16·8	17·2	17·4	17·4	17·2	17·2	17·1	17·1	17·0	17·0	17·0	17·0	17·0
December .	16·7	16·6	16·6	16·5	16·4	16·3	16·1	16·4	16·8	17·2	16·5	16·0	15·9	16·3	16·5	16·8	17·0	16·7	16·6	16·7	16·6	16·5	16·5	16·5	16·6	16·5
Means .	19·3	19·2	19·2	19·1	19·0	18·8	18·7	19·0	19·3	19·8	19·8	19·4	19·1	19·1	19·1	19·2	19·4	19·4	19·3	19·3	19·3	19·2	19·2	19·2	19·2	19·2

Summer.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
April .	20·5	20·5	20·7	20·6	20·6	20·4	20·9	21·8	22·1	22·0	21·4	20·9	20·4	19·8	19·5	19·8	20·6	20·9	20·6	20·4	20·2	20·2	20·3	20·3	20·3	20·7
May .	20·1	20·1	20·1	20·2	20·2	20·3	21·2	22·2	22·2	21·3	20·4	19·4	18·5	18·4	18·7	19·0	19·6	19·9	19·9	19·9	19·7	19·6	19·8	19·9	20·0	20·0
June .	19·7	19·8	19·9	19·9	20·0	20·1	21·3	22·0	22·0	21·2	20·2	19·1	18·4	18·3	18·3	18·4	19·0	19·7	19·7	19·2	19·3	19·3	19·4	19·5	19·6	19·7
July .	19·1	19·3	19·5	19·4	19·4	19·6	20·2	20·9	20·8	20·3	19·4	18·1	17·7	17·5	17·5	18·0	18·6	19·0	18·9	18·7	18·6	18·6	18·7	18·8	19·1	19·0
August .	18·6	18·7	18·7	18·8	18·8	19·0	19·8	20·9	21·0	20·2	18·9	17·7	16·9	16·7	16·9	17·2	17·8	18·2	18·1	18·2	18·2	18·1	18·2	18·3	18·5	18·5
September .	18·0	18·1	18·1	18·1	18·1	18·0	18·5	19·7	20·1	19·5	18·4	17·2	16·7	16·4	16·7	17·4	18·2	18·5	18·1	17·9	17·9	17·9	17·9	18·0	18·0	18·1
Means .	19·3	19·4	19·5	19·5	19·5	19·6	20·3	21·3	21·4	20·8	19·8	18·7	18·1	17·9	17·9	18·3	19·0	19·4	19·2	19·1	19·0	19·0	19·1	19·1	19·3	19·3

Diurnal Inequality of the Declination at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	+0·2	0	−0·1	−0·2	−0·3	−0·6	−0·9	−1·0	−0·8	+0·2	+0·9	+0·6	+0·1	+0·2	0	−0·2	−0·1	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·1	+0·1
February . .	+0·1	0	+0·1	−0·1	−0·2	−0·2	−0·4	0·6	−0·5	−0·1	+0·4	+0·4	+0·3	+0·1	0	0	+0·2	+0·3	+0·2	+0·2	+0·3	+0·1	+0·2	+0·1	+0·2
March . . .	−0·1	−0·2	−0·1	−0·3	−0·5	−0·7	−0·8	−0·2	+0·7	+1·7	+1·9	+1·7	+0·8	−0·1	−0·7	−0·5	−0·1	0	−0·1	0	−0·1	−0·3	−0·3	−0·3	−0·3
October . .	+0·1	+0·1	+0·1	−0·1	−0·2	−0·3	−0·1	+0·4	+0·9	+0·8	+0·2	−0·7	−0·8	−0·5	−0·5	+0·1	+0·3	+0·2	−0·1	0	−0·1	−0·2	−0·2	−0·1	0
November . .	+0·1	+0·1	0	0	−0·1	−0·3	−0·3	−0·1	0	−0·1	−0·2	−0·6	−0·6	−0·2	+0·2	+0·4	+0·4	+0·2	+0·2	+0·1	+0·1	0	0	0	0
December . .	+0·2	+0·1	+0·1	0	−0·1	−0·3	−0·4	−0·1	+0·3	+0·7	0	−0·5	−0·6	−0·2	0	+0·3	+0·5	+0·2	+0·1	+0·2	+0·1	0	0	0	+0·1
Means . .	+0·1	0	0	−0·1	−0·2	−0·4	−0·5	−0·2	+0·1	+0·6	+0·6	+0·2	−0·1	−0·1	−0·1	0	+0·2	+0·2	+0·1	+0·1	+0·1	0	0	0	0
Summer.																									
April . . .	−0·2	−0·2	0	−0·1	−0·1	−0·3	+0·2	+1·1	+1·4	+1·3	+0·7	+0·2	−0·3	−0·9	−1·2	−0·9	−0·1	+0·2	−0·1	−0·3	−0·5	−0·5	−0·4	−0·4	−0·4
May . . .	+0·1	+0·1	+0·1	+0·2	+0·2	+0·3	+1·2	+2·2	+2·2	+1·3	+0·4	−0·6	−1·5	−1·6	−1·3	−1·0	−0·4	−0·1	−0·1	−0·1	−0·3	−0·4	−0·2	−0·1	0
June . . .	0	+0·1	+0·2	+0·2	+0·3	+0·4	+1·6	+2·3	+2·3	+1·5	+0·5	−0·6	−1·3	−1·4	−1·4	−1·3	−0·7	0	0	−0·5	−0·4	−0·4	−0·3	−0·2	−0·1
July . . .	+0·1	+0·3	+0·5	+0·4	+0·4	+0·6	+1·2	+1·9	+1·8	+1·3	+0·4	−0·9	−1·3	−1·5	−1·5	−1·0	−0·4	0	−0·1	−0·3	−0·4	−0·4	−0·3	−0·2	+0·1
August . .	+0·1	+0·2	+0·2	+0·3	+0·3	+0·5	+1·3	+2·4	+2·5	+1·7	+0·4	−0·8	−1·6	−1·8	−1·6	−1·3	−0·7	−0·3	−0·4	−0·3	−0·3	−0·4	−0·3	−0·2	0
September . .	−0·1	0	0	0	0	−0·1	+0·4	+1·6	+2·0	+1·4	+0·3	−0·9	−1·4	−1·7	−1·4	−0·7	+0·1	+0·4	0	−0·2	−0·2	−0·2	−0·2	−0·1	−0·1
Means . .	0	+0·1	+0·2	+0·2	+0·2	+0·3	+1·0	+2·0	+2·1	+1·5	+0·5	−0·6	−1·2	−1·4	−1·4	−1·0	−0·3	+0·1	−0·1	−0·2	−0·3	−0·3	−0·2	−0·2	0

NOTE.—When the sign is + the magnet points to the East, and when − to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Toungoo from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
·38000 C. G. S.+ Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	827	831	826	824	825	827	829	832	837	842	848	848	846	843	838	835	833	832	831	829	826	827	825	826	830	833
February	827	836	829	826	829	831	831	836	843	849	856	857	859	855	847	839	833	830	828	826	822	824	823	826	823	836
March .	837	839	840	840	842	843	844	847	856	866	873	878	878	870	860	851	846	842	841	841	839	837	837	839	839	849
October .	856	853	853	854	856	858	859	858	859	869	876	881	880	873	868	862	858	856	855	853	852	851	851	851	852	860
November .	855	857	858	860	859	860	862	866	873	880	887	890	888	883	876	870	866	862	858	857	857	857	857	858	860	866
December .	854	855	857	857	857	857	860	863	868	871	876	879	877	869	864	859	855	855	856	856	855	855	857	857	858	861
Means	843	845	844	844	845	846	848	850	856	863	869	872	871	866	859	853	849	846	845	844	842	842	842	843	844	851
Summer.																										
April .	835	836	836	838	839	839	839	840	847	858	871	882	878	870	863	856	848	843	843	840	838	839	838	838	840	848
May .	837	838	838	839	839	837	838	841	847	855	864	868	866	862	857	848	840	836	836	837	836	836	837	840	841	845
June .	850	850	850	850	850	848	849	856	861	866	876	881	885	884	877	870	857	845	843	845	847	848	847	848	850	858
July .	851	851	851	852	853	854	853	857	859	862	872	879	884	881	874	868	862	856	853	854	854	853	855	855	854	860
August .	850	850	851	852	849	849	851	852	853	861	868	872	875	875	869	865	862	857	854	855	853	854	854	854	855	858
September .	851	851	851	852	851	852	854	854	853	860	868	869	871	869	865	859	856	854	851	853	852	851	851	851	851	856
Means .	846	846	846	847	847	847	847	850	853	860	870	875	877	874	868	861	854	849	847	847	847	847	847	848	849	854

Diurnal Inequality of the Horizontal Force at Toungoo as deduced from the preceding Table

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
													Winter.												
1911 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	−6	−2	−7	−9	−8	−6	−4	−1	+4	+9	+15	+15	+13	+10	+5	+2	0	−1	−2	−4	−7	−6	−8	−7	−3
February . .	−9	0	−7	−10	−7	−5	−5	0	+7	+13	+20	+21	+23	+19	+11	+3	−3	−6	−8	−10	−14	−12	−13	−10	−13
March . .	−12	−10	−9	−9	−7	−6	−5	−2	+7	+17	+24	+29	+29	+21	+11	2	−3	−7	−8	−8	−10	−12	−12	−10	−10
October . .	−4	−7	−7	−6	−4	−2	−1	−2	−1	+9	+16	+21	+20	+13	+8	+2	−2	−4	−5	−7	−8	−9	−9	−9	−8
November . .	−11	−9	−8	−6	−7	−6	−4	0	+7	+14	+21	+24	+22	+17	+10	+4	0	−4	−8	−9	−9	−9	−9	−8	−6
December . .	−7	−6	−4	−4	−4	−4	−1	+2	+7	+10	+15	+18	+16	+8	+3	−2	−6	−6	−5	−5	−6	−6	−4	−4	−3
Means . .	−8	−6	−7	−7	−6	−5	−3	−1	+5	+12	+18	+21	+20	+15	+8	+2	−2	−5	−6	−7	−9	−9	−9	−8	−7
													Summer.												
April . .	−13	−12	−12	−10	−9	−9	−9	−8	−1	+10	+23	+34	+30	+22	+15	+8	0	−5	−5	−8	−10	−9	−10	−10	−8
May . . .	−8	−7	−7	−6	−6	−8	−7	−4	+2	+10	+19	+23	+21	+17	+12	+3	−5	−9	−9	−8	−9	−9	−8	−5	−4
June . . .	−8	−8	−8	−8	−8	−10	−9	−2	+3	+8	+18	+23	+27	+26	+19	+12	−1	−13	−15	−13	−11	−10	−11	−10	+8
July . . .	−9	−9	−9	−8	−7	−6	−7	−3	−1	+2	+12	+19	+24	+21	+14	+8	+2	−4	−7	−6	−6	−7	−5	−5	−6
August . .	−8	−8	−7	−6	−9	−9	−7	−6	−5	+3	+10	+14	+17	17	+11	+7	+4	−1	−4	−3	−5	−4	−4	−4	−3
September . .	−5	−5	−5	−4	−5	−4	−2	−2	−3	+4	+12	+13	+15	+13	+9	+3	0	−2	−5	−3	−4	−5	−5	−5	−5
Means .	−8	−8	−8	−7	−7	−7	−7	−4	−1	+6	+16	+21	+23	+20	+14	+7	0	−5	−7	−7	−7	−7	−7	−6	−5

NOTE.—When the sign is + the H. F. is greater, and when − it is less than the mean.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Toungoo from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Hours.
	·16000 C. G. S.+												Winter.													
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	514	512	512	512	512	513	513	513	513	514	512	511	509	508	511	516	518	519	520	521	523	523	523	522	521	515
February .	515	515	516	516	516	516	517	516	517	516	514	512	513	515	517	519	519	521	522	524	526	528	528	529	529	519
March .	528	527	527	527	526	526	526	527	527	525	522	520	516	516	518	521	523	525	527	528	529	529	529	530	530	525
October .	550	550	549	550	549	550	552	551	549	543	537	535	535	540	543	546	547	545	545	547	548	548	549	550	549	546
November .	551	550	551	551	550	551	551	550	547	544	541	539	541	544	545	546	547	547	548	549	550	550	550	551	551	548
December .	539	538	538	538	538	538	537	538	535	528	522	523	525	529	533	533	536	536	536	538	538	538	539	539	540	535
Means .	533	532	532	532	532	532	533	533	531	528	525	523	523	525	528	531	532	532	533	535	536	536	536	537	537	531
													Summer.													
April .	527	527	528	529	529	528	530	530	526	522	518	516	516	518	520	525	528	528	527	528	527	529	529	529	529	526
May .	533	532	533	533	532	533	536	531	524	521	517	514	513	518	523	526	529	529	530	531	532	533	534	535	534	528
June .	538	539	538	537	537	538	540	539	536	531	530	532	532	534	539	543	543	541	538	538	539	539	539	539	537	538
July .	540	540	540	540	540	541	543	542	536	532	527	526	526	529	533	537	540	540	539	538	539	540	540	541	541	537
August .	538	538	537	537	538	539	543	542	534	524	518	517	521	527	530	534	537	537	535	536	538	538	539	539	539	534
September .	533	533	533	534	533	534	538	539	532	521	513	513	510	518	527	532	534	532	531	533	533	534	535	536	536	530
Means .	535	535	535	535	535	536	538	537	531	525	521	520	520	524	529	533	535	535	533	534	535	536	536	537	536	532

Diurnal Inequality of the Vertical Force at Toungoo as deduced from the preceding Table.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	−1	−3	−3	−3	−3	−2	−2	−2	−2	−1	−3	−4	−6	−7	−4	+1	+3	+4	+5	+6	+8	+8	+8	+7	+6
February	−4	−4	−3	−3	−3	−3	−2	−3	−2	−3	−5	−7	−6	−4	−2	0	0	+2	+3	+5	+7	+9	+9	+10	+10
March	+3	+2	+2	+2	+1	+1	+1	+2	+2	0	−3	−5	−9	−9	−7	−4	−2	0	+2	+3	+4	+4	+4	+5	+5
October	+4	+4	+3	+4	+3	+4	+6	+5	+3	−3	−9	−11	−11	−6	−3	0	+1	−1	−1	+1	+2	+2	+3	+4	+3
November	+3	+2	+3	+3	+2	+3	+3	+2	−1	−4	−7	−9	−7	−4	−3	−2	−1	−1	0	+1	+2	+2	+2	+3	+3
December	+4	+3	+3	+3	+3	+3	+2	+3	0	−7	−13	−12	−10	−6	−2	+1	+1	+1	+1	+3	+3	+3	+4	+4	+5
Means	+2	+1	+1	+1	+1	+1	+2	+2	0	−3	−6	−8	−8	−6	−3	0	+1	+1	+2	+4	+5	+5	+5	+6	+6
Summer.																									
April	+1	+1	+2	+3	+3	+2	+4	+4	0	−4	−8	−10	−10	−8	−6	−1	+2	+2	+1	+2	+1	+3	+3	+3	+3
May	+5	+4	+5	+5	+4	+5	+8	+3	−4	−7	−11	−14	−15	−10	−5	−2	+1	+1	+2	+3	+4	+5	+6	+7	+6
June	0	+1	0	−1	−1	0	+2	+1	−2	−7	−8	−6	−6	−4	+1	+5	+5	+3	0	0	+1	+1	+1	+1	−1
July	+3	+3	+3	+3	+8	+4	+	+5	−1	−5	−10	−11	−11	−8	−4	0	+3	+3	+2	+1	+2	+3	+3	+4	+4
August	+4	+4	+3	+3	+4	+5	+9	+8	0	−10	−16	−17	−13	−7	−4	0	+3	+3	+1	+2	+4	+4	+5	+5	+5
September	+3	+3	+3	+4	+3	+4	+8	+9	+2	−9	−17	−17	−20	−12	−3	+2	+4	+2	+1	+3	+3	+4	+5	+6	+6
Means	+3	+3	+3	+3	+3	+4	+6	+5	−1	−7	−11	−12	−12	−8	−3	+1	+3	+3	+1	+2	+3	+4	+4	+5	+4

NOTE.—When the sign is + the Vertical Force is more, and when — it is less than the mea .

Hourly Means of the Dip as determined at Toungoo from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter. 23°+																										
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	2·5	2·2	2·4	2·4	2·4	2·4	2·3	2·3	2·1	2·0	1·7	1·6	1·5	1·5	1·9	2·4	2·6	2·7	2·8	2·9	3·2	3·2	3·2	3·1	2·9	2·4
February .	2·6	2·3	2·5	2·7	2·5	2·5	2·6	2·3	2·2	1·9	1·5	1·4	1·4	1·7	2·1	2·5	2·7	2·9	3·0	3·3	3·5	3·6	3·7	3·7	3·7	2·5
March .	3·2	3·1	3·0	3·0	2·9	2·9	2·9	2·8	2·5	2·1	1·6	1·3	1·0	1·3	1·7	2·3	2·5	2·8	3·0	3·1	3·2	3·3	3·3	3·3	3·3	2·6
October .	4·3	4·4	4·3	4·3	4·2	4·2	4·3	4·3	4·1	[illegible]·3	2·7	2·3	2·3	3·0	3·3	3·7	4·0	3·9	3·9	4·1	4·3	4·3	4·3	4·4	4·3	3·8
November .	4·3	4·2	4·3	4·2	4·2	4·2	4·1	3·9	3·5	3·0	2·6	2·3	2·5	2·9	3·3	3·5	3·7	3·8	4·1	4·1	4·2	4·2	4·2	4·3	4·2	3·7
December .	3·5	3·4	3·3	3·3	3·3	3·3	3·2	3·1	2·7	2·1	1·5	1·5	1·7	2·3	2·7	3·1	3·2	3·2	3·2	3·3	3·4	3·4	3·4	3·4	3·5	2·9
Means .	3·4	3·3	3·3	3·3	3·3	3·3	5·2	3·1	2·9	2·4	1·9	1·7	1·7	2·1	2·5	2·9	3·1	3·2	3·3	3·5	3·6	3·7	3·7	3·7	3·7	3·0
Summer.																										
April .	3·2	3·2	3·3	3·3	3·2	3·1	3·3	3·3	2·7	2·1	1·4	0·9	1·0	1·4	1·8	2·4	2·9	3·0	2·9	3·1	3·1	3·2	3·3	3·3	3·2	2·7
May .	3·6	3·5	3·5	3·5	3·5	3·6	3·8	3·3	2·6	2·1	1·5	1·2	1·2	1·7	2·2	2·7	3·2	3·3	3·4	3·4	3·6	3·6	3·7	3·6	3·5	3·0
June .	3·5	3·6	3·5	3·5	3·5	3·6	3·7	3·4	3·1	2·5	2·1	2·1	2·0	2·2	2·8	3·3	3·7	3·9	3·8	3·7	3·7	3·7	3·7	3·7	3·5	3·3
July .	3·7	3·7	3·7	3·7	3·6	3·6	3·8	3·6	3·1	2·7	2·0	1·7	1·6	1·9	2·4	2·9	3·3	3·5	3·5	3·4	3·5	3·6	3·5	3·6	3·6	3·2
August .	3·5	3·5	3·5	3·4	3·6	3·7	3·9	3·8	3·2	2·2	1·5	1·3	1·5	1·9	2·3	2·8	3·1	3·3	3·2	3·2	3·5	3·4	3·5	3·5	3·5	3·0
September .	3·1	3·1	3·1	3·2	3·1	3·2	3·4	3·5	3·0	2·0	1·1	1·1	0·8	1·5	2·2	2·8	3·1	3·0	3·0	3·1	3·1	3·2	3·3	3·4	3·4	2·7
Means .	3·4	3·4	3·4	3·4	3·4	3·5	3·7	3·5	3·0	2·3	1·6	1·4	1·4	1·8	2·3	2·8	3·2	3·3	3·3	3·3	3·4	3·5	3·5	3·5	3·5	3·0

Diurnal Inequality of the Dip at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	′	′	′	′	′	′	′		′	′	′	′	′	′		′	′	′	′	′	′	′	′	′	′
January . .	+0·1	−0·2	0	0	0	0	−0·1	−0·1	−0·3	−0·4	−0·7	−0·8	−0·9	−0·9	−0·5	0	+0·2	+0·3	+0·4	+0·5	+0·8	+0·8	+0·8	+0·7	+0·5
February . .	+0·1	−0·2	0	+0·2	0	0	+0·1	−0·2	−0·3	−0·6	−1·0	−1·1	−1·1	−0·8	−0·4	0	+0·2	+0·4	+0·5	+0·8	+1·0	+1·1	+1·2	+1·2	+1·2
March . . .	+0·6	+0·5	+0·4	+0·4	+0·3	+0·3	+0·3	+0·2	−0·1	−0·5	−1·0	−1·3	−1·6	−1·3	−0·9	−0·3	−0·1	+0·2	+0·4	+0·5	+0·6	+0·7	+0·7	+0·7	+0·7
October . . .	+0·5	+0·6	+0·5	+0·5	+0·4	+0·4	+0·5	+0·5	+0·3	−0·5	−1·1	−1·5	−1·5	−0·8	−0·5	−0·1	+0·2	+0·1	+0·1	+0·3	+0·5	+0·5	+0·5	+0·6	+0·5
November . .	+0·6	+0·5	+0·6	+0·5	+0·5	+0·5	+0·4	+0·2	−0·2	−0·7	−1·1	−1·4	−1·2	−0·8	−0·4	−0·2	0	+0·1	+0·4	+0·4	+0·5	+0·5	+0·5	+0·6	+0·5
December . .	+0·6	+0·5	+0·4	+0·4	+0·4	+0·4	+0·3	+0·2	−0·2	−0·8	−1·4	−1·4	−1·2	−0·6	−0·2	+0·2	+0·3	+0·3	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5	+0·6
Means . .	+0·4	+0·3	+0·3	+0·3	+0·3	+0·3	+0·2	+0·1	−0·1	−0·6	−1·1	−1·3	−1·3	−0·9	−0·5	−0·1	+0·1	+0·2	+0·3	+0·5	+0·6	+0·7	+0·7	+0·7	+0·7
Summer.																									
April . . .	+0·5	+0·5	+0·6	+0·6	+0·5	+0·4	+0·6	+0·6	0	−0·6	−1·3	−1·8	−1·7	−1·3	−0·9	−0·3	+0·2	+0·3	+0·2	+0·1	+0·4	+0·5	+0·6	+0·6	+0·5
May . . .	+0·6	+0·5	+0·5	+0·5	+0·5	+0·6	+0·8	+0·3	−0·4	−0·9	−15	−1·8	−1·8	−1·3	−0·8	−0·3	+0·2	+0·3	+0·4	+0·4	+0·6	+0·6	+0·7	+0·6	+0·5
June . . .	+0·3	+0·3	+0·2	+0·2	+0·2	+0·3	+0·4	+0·1	−0·2	−0·8	−1·2	−1·2	−1·3	−1·1	−0·5	0	+0·4	+0·6	+0·5	+0·4	+0·4	+0·4	+0·4	+0·4	+0·2
July .	+0·5	+0·5	+0·5	+0·5	+0·4	+0·4	+0·6	+0·4	−0·1	−0·5	−1·2	−1·5	−1·6	−1·3	−0·8	−0·3	+0·1	+0·3	+0·3	+0·2	+0·3	+0·4	+0·3	+0·4	+0·4
August . . .	+0·5	+0·5	+0·5	+0·4	+0·6	+0·7	+0·9	+0·8	+0·2	−0·8	−1·5	−1·7	−1·5	−1·1	−0·7	−0·2	+0·1	+0·3	+0·2	+0·2	+0·5	+0·4	+0·5	+0·5	+0·5
September . .	+0·4	+0·4	+0·4	+0·5	+0·4	+0·5	+0·7	+0·8	+0·3	−0·7	−1·6	−1·6	−1·9	−1·2	−0·5	+0·1	+0·4	+0·3	+0·3	+0·4	+0·4	+0·5	+0·6	+0·7	+0·7
Means . .	+0·4	+0·4	+0·4	+0·4	+0·4	+0·5	+0·7	+0·5	0	−0·7	−1·4	−1·6	−1·6	−1·2	−0·7	−0·2	+0·2	+0·3	+0·3	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5

NOTE.—When the sign is + the Dip is more, and when — it is less than the mean.

F.—Tables of results at Kodaikānal.

Hourly Means of the Declination as determined at Kodaikānal from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
W 0°+													Winter.													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	58·0	58·1	58·1	58·2	58·5	58·6	58·8	58·9	58·9	58·3	57·6	57·6	57·9	58·0	57·8	57·9	57·8	57·9	57·9	57·9	57·8	57·9	57·9	58·0	58·0	58·1
February	57·8	58·0	58·1	58·2	58·3	58·4	58·5	58·7	58·6	58·1	57·7	57·4	57·5	57·0	56·9	57·1	57·4	57·7	58·0	58·0	58·0	58·0	58·1	58·1	58·0	57·9
March	58·5	58·5	58·5	58·6	58·7	58·7	58·9	59·1	58·4	57·6	57·1	56·9	57·5	57·8	58·2	58·2	57·9	57·9	58·0	58·4	58·4	58·5	58·5	58·5	58·5	58·2
October	62·0	62·0	62·0	62·1	62·1	62·2	62·2	61·9	61·7	62·0	62·3	62·7	62·5	62·0	61·8	61·6	61·4	61·8	62·0	62·0	62·1	62·2	62·1	62·0	62·0	62·0
November	62·6	62·6	62·6	62·7	62·9	63·0	63·0	62·9	62·6	62·7	63·0	62·9	62·6	62·2	62·1	62·0	62·1	62·3	62·2	62·3	62·4	62·4	62·4	62·4	62·4	62·5
December	63·0	63·0	62·9	63·0	63·1	63·1	63·2	63·2	62·8	62·6	62·6	63·2	63·0	62·8	62·4	62·4	62·5	62·8	62·9	62·8	62·9	63·0	63·0	63·0	62·9	62·9
Means	60·3	60·4	60·4	60·5	60·6	60·7	60·8	60·8	60·5	60·2	60·1	60·1	60·2	60·0	59·9	59·9	59·9	60·1	60·2	60·2	60·3	60·3	60·3	60·3	60·3	60·3
													Summer.													
April	58·7	58·6	58·7	58·7	58·8	58·8	58·6	57·9	57·9	58·3	58·6	59·0	59·7	59·9	59·5	59·0	58·8	58·7	58·5	58·8	59·0	59·0	58·9	58·8	58·8	58·8
May	59·3	59·3	59·3	59·3	59·2	59·3	58·6	58·0	57·9	58·6	59·5	60·5	60·9	60·6	59·9	59·4	59·1	59·0	59·2	59·5	59·7	59·7	59·6	59·5	59·4	59·4
June	59·9	59·8	59·7	59·6	59·5	59·3	58·8	58·5	58·8	59·5	60·3	61·3	61·7	61·8	61·5	61·0	60·5	60·3	60·2	60·4	60·5	60·4	60·3	60·2	60·0	60·2
July	60·0	59·8	59·7	59·7	59·7	59·6	59·4	58·6	58·7	59·5	60·4	61·0	61·4	61·3	61·1	60·8	60·4	60·2	60·2	60·6	60·7	60·6	60·6	60·1	60·0	60·2
August	60·8	60·7	60·6	60·6	60·6	60·5	59·9	58·7	58·7	59·4	60·5	61·2	61·8	61·9	61·7	61·4	60·9	60·7	60·8	61·0	61·0	61·0	61·0	60·9	60·8	60·7
September	61·5	61·5	61·4	61·4	61·4	61·5	61·1	60·2	59·9	60·6	61·4	62·5	63·1	62·9	62·4	61·7	61·2	61·1	61·3	61·4	61·6	61·6	61·6	61·5	61·4	61·5
Means	60·0	60·0	59·9	59·9	59·9	59·8	59·4	58·7	58·7	59·3	60·1	60·9	61·4	61·4	61·0	60·6	60·2	60·0	60·0	60·3	60·4	60·4	60·3	60·2	60·1	60·1

Diurnal Inequality of the Declination at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·1	0	0	−0·1	−0·4	−0·5	−0·7	−0·8	−0·8	−0·2	+0·5	+0·5	+0·2	+0·1	+0·3	+0·2	+0·3	+0·2	+0·2	+0·2	+0·3	+0·2	+0·2	+0·1	+0·1
February	+0·1	−0·1	−0·2	−0·3	−0·4	−0·5	−0·6	−0·8	−0·7	−0·2	+0·2	+0·5	+0·4	+0·9	+1·0	+0·8	+0·5	+0·2	−0·1	−0·1	−0·1	−0·1	−0·2	−0·2	−0·1
March	−0·3	−0·3	−0·3	−0·4	−0·5	−0·5	−0·7	−0·9	−0·2	+0·6	+1·1	+1·3	+0·7	+0·4	0	0	+0·3	+0·3	+0·2	−0·2	−0·2	−0·3	−0·3	−0·3	−0·3
October	0	0	0	−0·1	−0·1	−0·2	−0·2	+0·1	+0·3	0	−0·3	−0·7	−0·5	0	+0·2	+0·4	+0·6	+0·3	0	0	−0·1	−0·2	−0·1	0	0
November	−0·1	−0·1	−0·1	−0·2	−0·4	−0·5	−0·5	−0·4	−0·1	−0·2	−0·5	−0·4	−0·1	+0·3	+0·4	+0·5	+0·4	+0·2	+0·3	+0·2	+0·1	+0·1	+0·1	+0·1	+0·1
December	−0·1	−0·1	0	−0·1	−0·2	−0·2	−0·3	−0·3	+0·1	+0·3	+0·3	−0·3	−0·1	+0·1	+0·5	+0·5	+0·4	+0·1	0	+0·1	0	−0·1	−0·1	−0·1	0
Means	0	−0·1	−0·1	−0·2	−0·3	−0·4	−0·5	−0·5	−0·2	+0·1	+0·2	+0·2	+0·1	+0·3	+0·4	+0·4	+0·4	+0·2	+0·1	+0·1	0	0	0	0	0
Summer.																									
April	+0·1	+0·2	+0·1	+0·1	0	0	+0·2	+0·9	+0·9	+0·5	+0·2	−0·2	−0·9	−1·1	−0·7	−0·2	0	+0·1	+0·3	0	−0·2	−0·2	−0·1	0	0
May	+0·1	+0·1	+0·1	+0·1	+0·2	+0·1	+0·8	+1·4	+1·5	+0·8	−0·1	−1·1	−1·5	−1·2	−0·5	0	+0·3	+0·4	+0·2	−0·1	−0·3	−0·3	−0·2	−0·1	0
June	+0·3	+0·4	+0·5	+0·6	+0·7	+0·9	+1·4	+1·7	+1·4	+0·7	−0·1	−1·1	−1·5	−1·6	−1·3	−0·8	−0·3	−0·1	0	−0·2	−0·3	−0·2	−0·1	0	+0·2
July	+0·2	+0·4	+0·5	+0·5	+0·5	+0·6	+0·8	+1·6	+1·5	+0·7	−0·2	−0·8	−1·2	−1·1	−0·9	−0·6	−0·2	0	0	−0·4	−0·5	−0·4	−0·4	−0·2	+0·2
August	−0·1	0	+0·1	+0·1	+0·1	+0·2	+0·8	+2·0	+2·0	+1·3	+0·2	−0·5	−1·1	−1·2	−1·0	−0·7	−0·2	0	−0·1	−0·3	−0·3	−0·3	−0·3	−0·2	−0·1
September	0	0	+0·1	+0·1	+0·1	0	+0·4	+1·3	+1·6	+0·9	+0·1	−1·0	−1·6	−1·4	−0·9	−0·2	+0·3	+0·4	+0·2	+0·1	−0·1	−0·1	−0·1	0	+0·1
Means	+0·1	+0·1	+0·2	+0·2	+0·2	+0·3	+0·7	+1·4	+1·4	+0·8	0	−0·8	−1·3	−1·3	−0·9	−0·5	−0·1	+0·1	+0·1	−0·2	−0·3	−0·3	−0·2	−0·1	0

NOTE.—When the sign is + the magnet points to the East, and when — to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Kodaikānal from the selected quiet days in 1911.

37000 C. G. S. +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	490	488	486	488	488	488	488	493	502	514	522	537	543	540	531	519	508	500	497	495	495	493	491	493	492	504
February .	492	487	488	490	489	490	491	498	509	516	521	523	523	524	518	506	496	491	489	485	485	484	484	480	484	498
March .	491	491	493	494	495	495	495	505	522	541	555	560	553	538	524	515	508	501	500	497	495	494	494	494	495	511
October .	509	510	512	515	515	514	514	520	536	559	576	583	570	555	539	524	516	515	514	511	508	507	507	509	510	526
November .	516	517	518	518	519	520	521	530	546	565	571	567	559	545	532	527	524	522	519	518	518	517	517	518	519	530
December .	518	515	517	516	516	517	518	528	542	558	573	570	556	534	515	509	511	517	520	519	518	518	518	519	520	527
Means .	503	501	502	504	504	504	505	512	525	542	553	557	551	539	527	517	511	508	507	504	503	502	502	502	503	516
Summer.																										
April .	491	490	493	493	491	492	492	499	519	544	561	566	553	533	516	503	500	500	497	494	493	493	491	492	490	508
May .	494	495	495	494	492	494	495	502	519	540	550	556	548	533	512	494	488	491	495	493	493	498	496	496	497	507
June .	502	504	502	502	499	502	505	508	518	533	544	552	549	536	522	511	500	498	499	499	500	500	501	501	503	512
July .	501	501	505	504	503	502	503	504	514	532	548	558	557	544	531	516	506	501	503	503	503	504	504	504	505	515
August .	504	507	506	504	504	504	505	510	523	542	557	563	559	545	530	521	515	513	511	507	507	508	508	508	511	519
September .	510	510	511	511	511	511	511	517	535	559	578	586	577	562	543	529	519	515	516	514	511	511	510	511	511	528
Means .	500	501	502	501	500	501	502	507	521	542	556	564	557	542	526	512	505	503	504	502	501	502	502	502	503	515

Diurnal Inequality of the Horizontal Force at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	−14	−16	−18	−16	−16	−16	−16	−11	− 2	+10	+18	+33	+39	+36	+27	+15	+ 4	− 4	− 7	− 9	− 9	−11	−13	−11	−12
February	− 6	−11	−10	− 8	− 9	− 8	− 7	0	+11	+18	+23	+25	+25	+26	+20	+ 8	− 2	− 7	− 9	−13	−13	−14	−14	−18	−14
March	−20	−20	−18	−17	−16	−16	−16	− 6	+11	+30	+44	+49	+42	+27	+13	+ 4	− 3	−10	−11	−14	−16	−17	−17	−17	−16
October	−17	−16	−14	−11	−11	−12	−12	− 6	+10	+23	+50	+57	+44	+29	+13	− 2	−10	−11	−12	−15	−18	−19	−19	−17	−16
November	−14	−13	−12	−12	−11	−10	− 9	0	+16	+35	+41	+37	+29	+15	+ 2	− 3	− 6	− 8	−11	−12	−12	−13	−13	−12	−11
December	− 9	−12	−10	−11	−11	−10	− 9	+ 1	+15	+31	+46	+43	+29	+ 7	−12	−18	−16	−10	− 7	− 8	− 9	− 9	− 9	− 8	− 7
Means	−13	−15	−14	−12	−12	−12	−11	− 4	+ 9	+26	+37	+41	+35	+23	+11	+ 1	− 5	− 8	− 9	−12	−13	−14	−14	−14	−13
Summer.																									
April	−17	−18	−15	−15	−17	−16	−16	− 9	+11	+36	+52	+58	+45	+25	+ 8	− 5	− 8	− 8	−11	−14	−15	−15	−17	−16	−18
May	−13	−12	−12	−13	−15	−13	−12	− 5	+12	+33	+43	+49	+41	+26	+ 5	−13	−19	−16	−12	−14	−14	−14	−11	−11	−10
June	−10	− 8	−10	−10	−13	−10	− 7	− 4	+ 6	+21	+32	+40	+37	+24	+10	− 1	−12	−14	−13	−13	−12	−12	−11	−11	− 9
July	−14	−14	−10	−11	−12	−13	−12	−11	− 1	+17	+33	+43	+42	+29	+16	+ 1	− 9	−14	−12	−12	−12	−11	−11	−11	−10
August	−15	−12	−13	−15	−15	−15	−14	− 9	+ 4	+23	+38	+44	+40	+26	+11	+ 2	− 4	− 6	− 8	−12	−12	−11	−11	−11	− 8
September	−18	−18	−17	−17	−17	−17	−17	−11	+ 7	+31	+50	+58	+49	+34	+15	+ 1	− 9	−13	−12	−14	−17	−17	−18	−17	−17
Means	−15	−14	−13	−14	−15	−14	−13	− 8	+ 6	+27	+41	+49	+42	+27	+11	− 3	−10	−12	−11	−13	−14	−13	−13	−13	−12

NOTE.—When the sign is + the H.F. is greater, and when − it is less than the mean.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Kodaikānal from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter. ·02000 C. G. S.+																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	506	505	504	505	505	505	504	505	505	505	501	497	492	486	484	487	492	493	499	500	499	501	502	504	503	499
February	512	510	511	511	511	511	511	509	509	509	511	510	509	504	498	497	502	503	507	508	510	511	510	510	512	508
March	516	516	516	516	516	516	515	517	518	516	513	508	507	508	507	508	510	512	514	512	513	514	515	515	516	513
October	565	565	566	567	567	566	567	563	560	551	546	545	547	551	553	558	561	562	564	565	565	566	568	569	569	560
November	572	572	572	571	571	571	572	571	570	566	563	564	564	561	562	563	561	563	566	567	568	568	569	570	571	567
December	580	578	578	577	577	577	577	575	570	563	555	551	553	557	564	570	573	573	574	574	575	576	576	577	578	571
Means	542	541	541	541	541	541	541	540	539	535	532	529	529	528	528	531	533	534	537	538	538	539	540	541	542	536
Summer.																										
April	528	527	528	527	527	528	529	528	522	517	512	506	506	508	510	515	519	520	519	520	522	523	523	524	524	520
May	530	529	529	528	528	530	531	529	523	515	511	505	508	513	519	525	529	528	525	525	526	527	528	529	530	524
June	536	537	536	535	535	538	539	539	537	534	532	532	533	531	532	533	534	535	535	536	536	536	537	537	537	535
July	541	541	543	542	541	542	545	542	537	532	529	527	527	531	533	537	539	538	539	537	538	539	540	541	541	538
August	550	551	549	548	549	550	553	553	546	537	528	527	526	530	535	542	544	544	543	546	547	549	549	550	551	544
September	556	555	556	555	555	555	559	558	548	537	529	522	523	529	535	542	547	548	550	551	551	553	554	555	556	547
Means	540	540	540	539	539	541	543	542	536	529	524	520	521	524	527	532	535	536	535	536	537	538	539	539	540	535

Diurnal Inequality of the Vertical Force at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	+7	+6	+5	+6	+6	+6	+5	+6	+6	+6	+2	−2	−7	−13	−15	−12	−7	−6	0	+1	0	+2	+3	+5	+4
February	+4	+2	+3	+3	+3	+3	+3	+1	+1	+1	+3	+2	+1	−4	−10	−11	−6	−5	−1	0	+2	+3	+2	+2	+4
March	+3	+3	+3	+3	+3	+3	+2	+4	+5	+3	0	−5	−6	−5	−6	−5	−3	−1	+1	−1	0	+1	+2	+2	+3
October	+5	+5	+6	+7	+7	+6	+7	+3	0	−9	−14	−15	−13	−9	−7	−2	+1	+2	+4	+5	+5	+6	+8	+9	+9
November	+5	+5	+5	+4	+4	+4	+5	+4	+3	−1	−4	−3	−3	−6	−5	−4	−6	−4	−1	0	+1	+1	+2	+3	+4
December	+9	+7	+7	+6	+6	+6	+6	+4	−1	−8	−16	−20	−18	−14	−7	−1	+2	+2	+3	+3	+4	+5	+5	+6	+7
Means	+6	+5	+5	+5	+5	+5	+5	+4	+3	−1	−4	−7	−7	−8	−8	−5	−3	−2	+1	+2	+2	+3	+4	+5	+6
Summer.																									
April	+8	+7	+8	+7	+7	+8	+9	+8	+2	−3	−8	−14	−14	−12	−10	−5	−1	0	−1	0	+2	+3	+3	+4	+4
May	+6	+5	+5	+4	+4	+6	+7	+5	−1	−9	−13	−19	−16	−11	−5	+1	+5	+4	+1	+1	+2	+3	+4	+5	+6
June	+1	+2	+1	0	0	+3	+4	+4	+2	−1	−3	−3	−2	−4	−3	−2	−1	0	0	+1	+1	+1	+2	+2	+2
July	+3	+3	+5	+4	+3	+4	+7	+4	+1	−6	−9	−11	−11	−7	−5	−1	+1	0	+1	−1	0	+1	+2	+3	+3
August	+6	+7	+5	+4	+5	+6	+9	+9	+2	−7	−16	−17	−18	−14	−9	−2	0	0	−1	+2	+3	+5	+5	+6	+7
September	+9	+8	+9	+8	+8	+8	+12	+11	+1	−10	−18	−25	−24	−18	−12	−5	0	+1	+3	+4	+4	+6	+7	+8	+9
Means	+5	+5	+5	+4	+4	+6	+8	+7	+1	−6	−11	−15	−14	−11	−8	−3	0	+1	0	+1	+2	+3	+4	+4	+5

NOTE.—When the sign is + the Vertical Force is greater, and when −, it is less than the mean value.

W 2

Hourly Means of the Dip as determined at Kodaikānal from the selected quiet days in 1911.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
3°+													Winter.													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	49·5	49·4	49·3	49·4	49·4	49·4	49·3	49·4	49·3	49·2	48·8	48·4	47·9	47·3	47·2	47·6	48·1	48·2	48·8	48·9	48·8	49·0	49·1	49·3	49·2	48·8
February .	50·0	49·8	49·9	49·9	49·9	49·9	49·9	49·7	49·6	49·6	49·7	49·6	49·5	49·1	48·6	48·5	49·1	49·2	49·6	49·7	49·9	50·0	49·9	49·9	50·0	49·6
March .	50·4	50·4	50·4	50·4	50·3	50·3	50·3	50·4	50·4	50·1	49·7	49·2	49·2	49·4	49·3	49·5	49·7	49·9	50·1	50·0	50·1	50·2	50·3	50·3	50·3	50·0
October .	54·7	54·7	54·8	54·9	54·9	54·8	54·9	54·5	54·1	53·1	52·6	52·4	52·7	53·2	53·4	54·0	54·3	54·4	54·6	54·7	54·7	54·8	55·0	55·1	55·1	54·2
November .	55·3	55·3	55·3	55·2	55·2	55·2	55·3	55·1	55·0	54·5	54·2	54·3	54·3	54·1	54·3	54·4	54·3	54·5	54·8	54·9	54·9	55·0	55·0	55·1	55·2	54·8
December .	56·0	55·9	55·9	55·8	55·8	55·8	55·8	55·5	55·0	54·2	53·4	53·1	53·3	53·8	54·6	55·2	55·4	55·4	55·5	55·5	55·6	55·7	55·7	55·8	55·8	55·2
Means .	52·7	52·6	52·6	52·6	52·6	52·6	52·6	52·4	52·2	51·8	51·4	51·2	51·2	51·2	51·2	51·5	51·8	51·9	52·2	52·3	52·3	52·5	52·5	52·6	52·6	52·1
													Summer.													
April .	51·5	51·4	51·5	51·4	51·4	51·5	51·5	51·4	50·7	50·1	49·6	49·0	49·1	49·4	49·7	50·2	50·6	50·7	50·6	50·7	50·9	51·0	51·0	51·1	51·1	50·7
May .	51·6	51·5	51·5	51·4	51·5	51·6	51·7	51·5	50·8	50·0	49·6	49·0	49·3	49·8	50·5	51·2	51·6	51·5	51·2	51·2	51·3	51·4	51·4	51·5	51·6	51·0
June .	52·1	52·2	52·1	52·0	52·1	52·3	52·4	52·4	52·1	51·8	51·5	51·5	51·6	51·5	51·6	51·8	52·0	52·1	52·1	52·1	52·1	52·1	52·2	52·2	52·2	52·0
July .	52·6	52·6	52·7	52·7	52·6	52·7	52·9	52·7	52·1	51·6	51·2	51·0	51·0	51·4	51·7	52·1	52·4	52·3	52·4	52·2	52·3	52·4	52·5	52·6	52·6	52·2
August .	53·4	53·5	53·3	53·2	53·3	53·4	53·7	53·6	52·9	52·0	51·1	50·9	50·9	51·3	51·9	52·6	52·8	52·8	52·7	53·0	53·1	53·3	53·3	53·4	53·4	52·7
September .	53·9	53·8	53·9	53·8	53·8	53·8	54·2	54·0	53·0	51·9	51·0	50·3	50·5	51·1	51·8	52·5	53·0	53·1	53·3	53·4	53·4	53·6	53·7	53·8	53·9	52·9
Means .	52·5	52·5	52·5	52·4	52·5	52·6	52·7	52·6	51·9	51·2	50·7	50·3	50·4	50·8	51·2	51·7	52·1	52·1	52·1	52·1	52·2	52·3	52·4	52·4	52·5	51·9

Diurnal Inequality of the Dip at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1911 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	+0·7	+0·6	+0·5	+0·6	+0·6	+0·6	+0·5	+0·6	+0·5	+0·4	0	−0·4	−0·9	−1·5	−1·6	−1·2	−0·7	−0·6	0	+0·1	0	+0·2	+0·3	+0·5	+0·4
February . .	+0·4	+0·2	+0·3	+0·3	+0·3	+0·3	+0·3	+0·1	0	0	+0·1	0	−0·1	−0·5	−1·0	−1·1	−0·5	−0·4	0	+0·1	+0·3	+0·4	+0·3	+0·3	+0·4
March . . .	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·4	+0·4	+0·1	−0·3	−0·8	−0·8	−0·6	−0·7	−0·5	−0·3	−0·1	+0·1	0	+0·1	+0·2	+0·3	+0·3	+0·3
October . . .	+0·5	+0·5	+0·6	+0·7	+0·7	+0·6	+0·7	+0·3	−0·1	−1·1	−1·6	−1·8	−1·5	−1·0	−0·8	−0·2	+0·1	+0·2	+0·4	+0·5	+0·5	+0·6	+0·8	+0·9	+0·9
November . .	+0·5	+0·5	+0·5	+0·4	+0·4	+0·4	+0·5	+0·3	+0·2	−0·3	−0·6	−0·5	−0·5	−0·7	−0·5	−0·4	−0·5	−0·3	0	+0·1	+0·1	+0·2	+0·2	+0·3	+0·4
December . .	+0·8	+0·7	+0·7	+0·6	+0·6	+0·6	+0·6	+0·3	−0·2	−1·0	−1·8	−2·1	−1·9	−1·4	−0·6	0	+0·2	+0·2	+0·3	+0·3	+0·4	+0·5	+0·5	+0·6	+0·6
Means . .	+0·6	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·3	+0·1	−0·3	−0·7	−0·9	−0·9	−0·9	−0·9	−0·6	−0·3	−0·2	+0·1	+0·2	+0·2	+0·4	+0·4	+0·5	+0·5
Summer.																									
April . . .	+0·8	+0·7	+0·8	+0·7	+0·7	+0·8	+0·8	+0·7	0	−0·6	−1·1	−1·7	−1·6	−1·3	−1·0	−0·5	−0·1	0	−0·1	0	+0·2	+0·3	+0·3	+0·4	+0·4
May . .	+0·6	+0·5	+0·5	+0·4	+0·5	+0·6	+0·7	+0·5	−0·2	−1·0	−1·4	−2·0	−1·7	−1·2	−0·5	+0·2	+0·6	+0·5	+0·2	+0·2	+0·3	+0·4	+0·4	+0·5	+0·6
June . . .	+0·1	+0·2	+0·1	0	+0·1	+0·3	+0·4	+0·4	+0·1	−0·2	−0·5	−0·5	−0·4	−0·5	−0·4	−0·2	0	+0·1	+0·1	+0·1	+0·1	+0·1	+0·2	+0·2	+0·2
July . . .	+0·4	+0·4	+0·5	+0·5	+0·4	+0·5	+0·7	+0·5	−0·1	−0·6	−1·0	−1·2	−1·2	−0·8	−0·5	−0·1	+0·2	+0·1	+0·2	0	+0·1	+0·2	+0·3	+0·4	+0·4
August . . .	+0·7	+0·8	+0·6	+0·5	+0·6	+0·7	+1·0	+0·9	+0·2	−0·7	−1·6	−1·8	−1·8	−1·4	−0·8	−0·1	+0·1	+0·1	0	+0·3	+0·4	+0·6	+0·6	+0·7	+0·7
September . .	+1·0	+0·9	+1·0	+0·9	+0·9	+0·9	+1·3	+1·1	+0·1	−1·0	−1·9	−2·6	−2·4	−1·8	−1·1	−0·4	+0·1	+0·2	+0·4	+0·5	+0·5	+0·7	+0·8	+0·9	+1·0
Means . .	+0·6	+0·6	+0·6	+0·5	+0·6	+0·7	+0·8	+0·7	0	−0·7	−1·2	−1·6	−1·5	−1·1	−0·7	−0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·4	+0·5	+0·5	+0·6

NOTE.—When the sign is + the Dip is more, and when — it is less than the mean.

G.—Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1911-12.

DETAIL SURVEY STATIONS.

Serial No.	Name of Stations.	Latitude. °	′	″	Longitude. °	′	″	Dip. °	′	Declination.	°	′	Horizontal Force. C. G. S.	REMARKS.
274D	Hirapur	19	48	0	79	6	50	25	26	W.	0	15	0·3732	H is derived from mean m_0 throughout.
275D	Ergohan	19	41	10	79	0	50	25	2	„	0	45	0·3726	
276D	Marnri Guda	19	36	0	78	37	50	25	17	E.	0	9	0·3646	
277D	Sonepali	19	24	10	78	34	0	23	28	„	0	19	0·3754	
278D	Omri	19	26	20	78	45	20	24	0	„	1	0	0·3794	
279D	Omri	19	31	50	78	55	40	25	53	„	4	31	0·3582	
280D	Indapur	19	28	10	79	9	10	24	38	W.	0	2	0·3712	
281D	Karki	19	36	10	79	13	0	24	10	E.	0	4	0·3704	
282D	Temburwai	19	41	20	79	21	0	24	29	„	0	17	0·3743	
283D	Kanargao	19	23	20	79	21	50	24	35	„	0	5	0·3734	
284D	Ginejari	19	12	10	79	13	50	23	52	„	0	2	0·3734	
285D	Rali	18	58	0	79	19	40	23	20	W.	0	6	0·3755	
286D	Kāsipet	18	57	10	79	6	40	25	10	„	0	30	0·3695	
287D	Kohal	19	10	20	78	57	50	23	0	E.	0	5	0·3745	
288D	Birsaipet	19	16	40	78	48	30	23	32	„	0	23	0·3728	
289D	Itkeal	19	13	50	78	37	0	25	1	W.	1	2	0·3830	
290D	Yellagudpa	19	2	50	78	44	10	23	24	„	0	17	0·3735	
291D	Mamda	19	4	20	78	31	40	23	28	E.	0	12	0·3725	
292D	Warasakota	18	54	50	78	32	20	23	1	„	0	17	0·3765	
293D	Koretla	18	49	10	78	42	30	23	27	„	0	11	0·3748	
294D	Kotapet	18	46	40	79	12	10	23	36	„	0	35	0·3746	
295D	Ramgundam	18	47	40	79	27	10	22	53	W.	0	4	0·3691	
296D	Ragampet	18	38	0	79	8	50	23	3	„	0	19	0·3843	
297D	Yeldevee	18	27	10	79	15	10	22	30	„	1	16	0·3800	
298D	Elgundal	18	25	30	79	3	10	22	36	E.	0	21	0·3722	
299D	Korem	18	31	50	78	54	40	22	3	„	0	25	0·3743	
300D	Roodrangee	18	37	50	78	41	30	22	34	W.	0	20	0·3729	
301D	Bimgul	18	42	10	78	27	10	24	18	„	0	9	0·3744	
302D	Cheemulpully	18	39	50	78	31	40	22	35	„	0	7	0·3767	
303D	Sircilla	18	22	40	78	48	20	22	28	„	0	22	0·3791	
304D	Vemalkonda	17	21	10	79	7	50	19	52	„	0	10	0·3796	
305D	Ibrahīmpatan	17	12	30	78	37	40	19	26	„	0	20	0·3781	
306D	Khampel	22	37	20	76	3	10	30	47	E.	1	5	0·3637	
307D	Nimkhera	22	31	40	76	19	20	30	17	„	0	48	0·3662	
308D	Kantaphor	22	34	40	76	33	50	30	54	„	0	31	0·3650	
309D	Ajnas	22	33	30	76	50	20	30	22	„	0	53	0·3650	
310D	Harangaon	22	45	0	76	58	0	29	40	„	1	35	0·3670	
311D	Daulatpur	22	53	30	76	55	50	31	34	„	1	24	0·3663	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1911-12—continued.

DETAIL SURVEY STATIONS—*continued.*

Serial No.	Name of Stations.	Latitude.			Longitude.			Dip.		Declination.			Horizontal Force.	REMARKS.
		°	′	″	°	′	″	°	′		°	′	C. G. S.	
312D	Ashta	23	1	30	76	43	40	31	12	E.	0	47	0·3677	H is derived from mean m_0 throughout.
313D	Tappa	22	50	50	76	28	40	31	9	„	0	58	0·3640	
314D	Sonkach	22	58	40	76	20	10	31	15	„	0	57	0·3615	
315D	Dewas	22	58	0	76	3	40	31	15	„	0	32	0·3572	
316D	Manglia	22	49	0	75	55	30	30	23	„	1	17	0·3653	
317D	Sewangaon	21	2	10	77	57	0	26	50	„	0	20	0·3703	
318D	Ashti	21	12	20	78	11	0	27	57	„	1	1	0·3680	
319D	Karanja	21	10	0	78	24	40	28	8	„	0	45	0·3707	
320D	Chikhli	21	5	50	78	36	30	27	28	„	0	41	0·3736	
321D	Bāzārgaon	21	8	20	78	45	50	27	42	„	0	51	0·3582	
322D	Kalmeshwar	21	14	0	78	54	40	27	34	„	0	15	0·3700	
323D	Bhoogaon	21	5	0	79	20	10	27	24	„	0	29	0·3708	
324D	Panchgaon	21	1	0	79	10	40	27	30	„	0	34	0·3699	
325D	Gûmgaon	20	59	20	79	1	0	27	36	„	0	10	0·3770	
326D	Sindi	20	48	40	78	53	10	26	56	„	0	12	0·3702	
327D	Hingni	20	55	0	78	43	0	27	46	„	0	11	0·3689	
328D	Anji	20	50	40	78	32	20	27	21	„	0	37	0·3702	
329D	Kinhāla	20	54	40	78	22	0	27	54	„	0	23	0·3641	
330D	Arvi	20	59	50	78	13	10	27	42	„	0	34	0·3681	
331D	Rasūlābād	20	46	10	78	21	50	25	51	„	0	29	0·3666	
332D	Chāndur	20	48	20	77	59	10	28	12	„	0	6	0·3678	
333D	Dhāmak	20	36	0	77	57	20	26	20	„	0	17	0·3675	
334D	Babūlgaon	20	33	30	78	10	0	26	41	„	0	37	0·3676	
335D	Bhidi	20	34	30	78	24	0	26	20	„	0	42	0·3702	
336D	Khangaon	20	29	30	78	33	0	25	51	„	0	32	0·3702	
337D	Waigaon	20	38	10	78	36	0	27	21	„	0	41	0·3700	
338D	Hinganghat	20	33	0	78	49	10	26	41	„	0	31	0·3771	
339D	Kora	20	30	40	79	5	50	27	3	W.	0	2	0·3697	
340D	Girar	20	39	20	79	6	40	26	25	E.	0	22	0·3724	
341D	Nand	20	39	0	79	17	50	26	39	„	0	30	0·3719	
342D	Amgaon	20	50	10	79	9	50	26	39	„	0	28	0·3711	
343D	Gondia	21	27	30	80	11	50	28	22	„	0	35	0·3701	
344D	Tumsar	21	15	50	80	17	50	28	4	„	0	31	0·3721	
345D	Dulee	21	5	40	80	13	20	27	39	„	0	25	0·3717	
346D	Shirpur	21	4	30	80	26	30	27	26	„	0	26	0·3737	
347D	Pathri	21	5	50	80	41	20	27	48	„	0	33	0·3719	
348D	Chipah	21	10	20	80	52	20	27	54	„	0	35	0·3719	

***Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1911-12*—continued.**

DETAIL SURVEY STATIONS—*concluded.*

Serial No.	Name of Stations.	Latitude.			Longitude.			Dip.		Declination.			Horizontal Force.	REMARKS.
		°	'	"	°	'	"	°	'		°	'	C. G. S.	
349D	Bhordih . .	21	17	50	80	56	40	28	9	E.	0	36	0·3720	H is derived from mean m_0 throughout.
350D	Khairagarh .	21	25	50	80	58	20	28	28	„	0	38	0·3707	
351D	Luchna . .	21	22	0	80	48	40	28	20	„	0	41	0·3710	

RE-OBSERVED FIELD STATIONS.

Serial No.	Name of Stations.	Latitude.			Longitude.			Dip.		Declination.			Horizontal Force.	REMARKS.
380	Alir . . .	17	38	30	79	2	50	20	32	W.	0	4	0·3782	H is derived from mean m_0 throughout.
619	Thuria . .	22	46	10	76	41	20	30	10	„	1	3	0·3645	
620	Hat Piplia . .	22	46	0	76	17	10	31	12	„	0	16	0·3637	
717	Thaviogpully .	18	16	40	79	6	30	21	56	„	0	19	0·3730	
718	Pedapali . .	18	36	30	79	22	30	22	22	E.	1	6	0·3787	
734	Shamshābād .	17	15	30	78	23	50	20	4	W.	0	32	0·3764	
735	Narainpur , .	17	10	0	78	52	40	19	35	„	0	34	0·3773	
742	Jaktiyal . .	18	47	30	78	54	40	24	9	„	1	1	0·3783	
743	Tandur . .	19	9	0	79	26	40	23	52	„	0	4	0·3752	
747	Danura . .	19	46	50	78	45	10	25	56	E.	0	26	0·3728	
748	Kupti . .	19	21	10	78	25	10	23	24	„	0	4	0·3725	
769	Salekasa . .	21	17	30	80	30	40	27	55	„	0	21	0·3791	
775	Kamptee . .	21	12	30	79	12	40	27	58	„	0	35	0·3690	
776	Paunar . .	20	46	50	78	42	40	26	40	„	0	9	0·3696	
778	Dhamangaon .	20	46	50	78	8	40	26	45	„	0	31	0·3679	
802	Katol . .	21	16	0	78	35	50	27	51	„	0	49	0·3694	
803	Umrer . .	20	51	0	79	20	0	27	47	„	0	54	0·3708	
1331	Mussoorie . .	30	27	40	78	5	10	44	15	„	2	30	0·3309	

REPEAT STATIONS.

Serial No.	Name of Stations.	Latitude.			Longitude.			Dip.		Declination.			Horizontal Force.	REMARKS.
I	Udaipur . .	24	35	33	73	41	57	34	23	E.	1	16	0·3521	H is derived from mean m_0 throughout.
II	Karāchi . .	24	49	50	67	2	2	34	43	„	1	40	0·3446	
III	Quetta . .	30	11	52	67	0	20	43	35	„	3	1	0·3216	
IV	Bahāwalpur .	29	23	27	71	40	37	42	39	„	2	48	0·3301	
V	Rāwalpindi .	33	35	16	73	3	6	48	43	„	3	41	0·3102	
VI	Bharatpur .	27	13	27	77	29	28	39	11	„	1	48	0·3449	
VII	Bangalore .	12	59	35	77	35	58	10	16	W.	0	57	0·3823	
VIII	Dharwar .	15	27	26	74	59	35	15	53	„	0	29	0·3766	
X	Fyzābad . .	26	47	27	82	7	40	38	24	E.	1	29	0·3533	
XI	Sambalpur .	21	28	3	83	58	24	28	11	„	0	32	0·3735	
XII	Waltair . .	17	42	57	83	19	1	21	40	W.	0	4	0·3793	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1911-12—continued.

REPEAT STATIONS—continued.

Serial No.	Name of Stations.	Latitude. °	′	″	Longitude. °	′	″	Dip. °	′	Declination.	°	′	Horizontal Force. C.G.S.	REMARKS.
XIV	Gaya	24	46	30	84	58	54	34	36	E.	0	52	0·3660	H is derived from mean m_0 throughout.
XV	Secunderābād	17	27	11	78	29	16	20	33	,,	0	0	0·3800	
XVI	Bhusāval	21	2	46	75	47	18	27	30	,,	0	36	0·3681	
XVII	Jubbulpore	23	8	57	79	56	44	31	34	,,	0	44	0·3653	
XXI	Silchar or Cachar	24	49	43	92	47	21	34	53	,,	0	50	0·3692	
XXII	Dibrugarh	27	29	24	94	55	40	39	40	,,	0	51	0·3584	
XXIII	Port Blair	11	39	10	92	43	13	6	17	W.	0	20	0·3965	
46	Ruk Junction	27	48	20	68	38	20	39	51	E.	2	2	0·3342	
71	Lahore	31	35	50	74	18	50	46	18	,,	2	48	0·3202	
88	Peshāwar	34	0	40	71	33	40	49	10	,,	3	49	0·3072	
92	Kundian	32	27	30	71	23	20	47	58	,,	3	27	0·3088	
105	Sachin	21	4	40	72	52	40	27	50	,,	0	20	0·3649	
124	Bikanir	28	0	40	73	18	50	40	28	,,	1	58	0·3377	
130	Ajmere	26	27	30	74	38	30	37	37	,,	1	52	0·3459	
134	Mirpur khās	25	31	40	69	0	40	36	7	,,	1	52	0·3438	
139	Viramgām	23	8	10	72	3	30	31	38	,,	1	3	0·3563	
172	Dhond	18	28	0	74	35	10	22	40	,,	0	18	0·3712	
175	Hotgi	17	33	40	76	0	20	20	50	,,	0	5	0·3757	
187	Perambūr	13	6	40	80	15	0	10	33	W.	0	54	0·3839	
216	Mirāj	16	49	10	74	38	10	19	46	,,	0	13	0·3765	
223	Manmād	20	14	40	74	26	20	27	8	E.	1	5	0·3675	
232	Delhi	28	40	20	77	14	20	41	30	,,	1	55	0·3399	
283	Sirsā	29	32	10	75	2	40	42	48	,,	2	30	0·3328	
337	Tanjore	10	46	40	79	8	20	4	49	W.	1	27	0·3822	
375	Parbhani	19	15	20	76	46	50	24	56	E.	0	34	0·3710	
384	Bezwāda	16	31	0	80	36	50	18	0	W.	0	36	0·3817	
483	Manikpur	25	3	10	81	5	20	35	25	E.	1	10	0·3587	
489	Monghyr	25	23	10	86	27	50	35	47	,,	1	5	0·3626	
500	Sini	22	47	0	85	56	50	30	35	,,	0	47	0·3738	
544	Bārān	25	5	30	76	30	30	35	36	,,	1	19	0·3526	
557	Indore	22	42	10	75	52	40	31	0	,,	0	41	0·3680	
573	Cawnpore	26	27	0	80	21	0	37	48	,,	1	33	0·3535	
699	Berhampur (Ganjam).	19	18	10	84	48	40	23	52	,,	0	2	0·3808	
746	Chanda	19	57	50	79	17	40	25	22	,,	0	23	0·3742	
765	Raipur	21	15	50	81	38	20	28	12	,,	0	32	0·3719	
779	Amraoti	20	55	30	77	45	50	27	50	,,	0	11	0·3647	
831	Sāntāhār	24	48	10	88	59	20	34	41	,,	1	2	0·3670	
871	Laksam	23	15	40	91	7	20	31	50	,,	0	41	0·3738	
961	Mandalay	22	0	50	96	6	30	29	19	,,	0	23	0·3807	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1911-12—concluded.

REPEAT STATIONS—concluded.

Serial No.	Name of Stations.	Latitude.			Longitude.			Dip.		Declination.			Horizontal Force.	REMARKS.
		°	′	″	°	′	″	°	′		°	′	C.G.S.	
976	Myitkyina . .	25	23	20	97	24	10	36	17	E.	1	19	0·3622	H is derived from mean m_o throughout.
977	Bhamo . .	24	15	30	97	13	10	33	47	"	0	39	0·3736	
1068	Prome . .	18	49	40	95	13	20	22	48	"	0	11	0·3886	
1071	Bassein . .	16	46	20	94	44	30	18	12	"	0	7	0·3926	
1195	Moulmein . .	16	29	40	97	37	30	17	40	"	0	17	0·3940	
1338	Barmer . .	25	44	40	71	26	40	36	38	"	1	49	0·3433	

NOTE.—The above values of Dip, Declination and Horizontal Force are uncorrected for secular change, diurnal variation, instrumental differences, etc., and are to be considered preliminary values only.

All Longitudes are referable to that of the Madras Observatory taken at the value 80° 14′ 47″ east from Greenwich.

PART VII.—REPRODUCING OFFICES.

PHOTO.-LITHO. OFFICE.

BY CAPTAIN C. M. THOMPSON, I.A.

Photo-Branch.—The outturn of negatives with the cost per 100 square inches for the last three years was as follows :—

Year.	Number of negatives.	Area in square inches.	Cost per 100 square inches.
			Rs. A. P.
1909-10 . . .	3,098	1,943,889	0 5 7
1910-11 . . .	2,905	1,786,295	0 6 0
1911-12 . . .	3,882	2,157,820	0 4 11

No changes of importance have been made in the methods or formulæ of the negative section. The improvement due to the introduction of iron base cameras, iron stands and Cooke lenses has been well maintained, and a still further improvement has been made by the use of office made silver nitrate. This chemical manufactured locally out of silver recovered from our residue tanks, is cheaper than that obtained from home and this enables the intensifying baths to be kept up to full strength at less cost. The quality of the negatives has improved owing to the greater density obtained in the stronger baths. Although the above table shows a large increase in outturn, the cost of the English silver nitrate used has decreased by Rs. 540.

The large Zeiss "Apochromat Planar" lens and prism indented for in 1906 arrived. The total cost of the lens and prism was £521. The lens has a focal length of 1700 mm. and works at an aperture of $\frac{F}{12\cdot5}$. Pending the conversion of No. 1 camera into an iron base camera with an iron stand, it has been found impossible to employ this lens owing to the vibration of the present apparatus. The camera and stand should be ready by December.

A glass plate polishing machine has been installed this year. This should effect a saving, as it will be possible to repolish tarnished negative glasses which would be otherwise useless.

The outturns of the Retouching, Helio and Vandyke, and Photo. Engraving Sections for the last three years were as follows :—

Retouching Section.

Year.	Black plates.	Colour plates.	Total.
1909-10	1,121	2,267	3,388
1910-11	896	2,229	3,125
1911-12	1,170	2,841	4,011

Helio and Vandyke Section.

Year.	Helios.	D. Z. Plates.	Total.
1909-10	3,243	359	3,602
1910-11	2,851	606	3,457
1911-12	3,991	534	4,525

Photo-Engraving Section.

Year.	No. of square inches.	Half-tone pulls.	Line pulls.	Total.
1909-10 . . .	15,091	114,846	68,390	183,236
1910-11 . . .	9,206	102,900	111,300	214,200
1911-12 . . .	13,223	60,056	437,820	497,876

The value of the work of Photo-Engraving Section exceeded the cost by Rs. 2,884-14-2.

Litho Branch.—The outturns for the last three years were as follows:—

Year.	Miscellaneous Departmental work.		Miscellaneous extra departmental work.		Total.	
	Maps.	Pulls.	Maps.	Pulls.	Maps.	Pulls.
1909-10 . .	2,697	1,149,302	1,053	424,878	3,750	1,574,180
1910-11 . .	2,559	833,762	1,104	549,385	3,663	1,383,147
1911-12 . .	2,686	1,045,426	1,263	519,070	3,949	1,564,496

It will be noticed that, while the outturn of pulls in the Litho. Section is practically the same as in 1909-10, the outturn of negatives and plates has increased materially. This is due to the greater use now made of blue prints and reductions for fair drawing by which much labour is saved in circle and party offices.

An offset machine for printing from rubber has been recently installed, but, pending the arrival of a proving press from home, it has only been used for direct printing. The offset method of printing it is hoped will offer material advantages in the printing of our 1-inch standard sheets, but as yet no definite opinion on this point can be given.

Type-Printing Section.—The outturns for the last three years were as follows:—

Year.	Pages or items.	Copies.	Impressions.
1909-10	12,185	1,435,093	2,615,735
1910-11	14,604	1,235,161	2,104,755
1911-12	7,988	1,131,012	2,014,766

The type-printing outturn shows a decrease owing to the fact that the work of printing the "Professional" forms has been transferred to the Dehra Dūn Office, also that the blocks and weather charts previously printed in the Type-Printing Section are now printed in the Photo-Engraving Section.

General.—The general increase of work has shown that the space allotted to the Photo.-Litho Office is now inadequate. More room is required for nearly every branch, especially for cameras in the Studio for the Helio Section and for negative and paper storage.

A marked advance has been made in the rate of progress of the publication of standard sheets. The first modern standard sheets in colours took some 8 months to publish. This time has now been considerably reduced and some sheets have recently been published within three months of the date of their receipt at head-quarters. This increase in speed is due to all hands, notably the men in the duffing section, becoming more expert in their duties.

The cost of the office and the value of the total office outturn at cost rates for the past three years were as follows:—

Year.	Cost of office.	Value of outturn at cost rate.
	Rs.	Rs.
1909-10	1,54,494	2,13,894
1910-11	1,64,193	1,77,900
1911-12	1,47,867*	2,01,394

* This decrease in the cost of the office is almost entirely due to reductions in expenditure on establishments.

APPENDIX I.

SYNOPSIS OF GEODETIC WORK IN THE VICINITY OF DEHRA DUN.

(*Vide* Map 12.)

LIST OF STATIONS.

Name of Station	Geodetic Latitude	Geodetic Longitude	Height	Remarks
	° ′ ″	° ′ ″	*feet*	
Amsot	30 22 44·86	77 41 14·77	3140	Latitude.
Asarory	30 14 25	77 58 3	2467	Pendulum.
Bahak*	30 45 5·22	78 13 37·26	9715	Latitude.
Bajamara*	30 45 56·20	77 54 0·19	9681	Latitude.
Banog	30 28 36·91	78 0 55·96	7433	Lat. and Azimuth.
Bulawâla	30 6 51·29	77 59 11·27	2432	Latitude.
Dehra Dun Base (E. End)	30 17 7·35	77 58 30·74	1967	Latitude.
Dehra Dun (Haig Observatory)	30 19 28·73	78 3 22·12	2240	Lat., Long., Az., Pendm., and Stand. B. M. near this point.
Fatehpur	30 25 53	77 43 37	1434	Pendulum.
Hardwar	29 56 29	78 9 19	949	Pendulum.
Hatni	30 13 1·52	77 52 19	3069	Latitude.
Kalsi	30 31 8	77 50 26	1684	Pendulum.
Khujnaur	30 16 23·63	77 52 58·67	2576	Latitude.
Kidarkanta*	31 1 21·71	78 10 23·74	12509	Latitude.
Lachkua	30 4 34·24	78 1 41·67	2674	Latitude.
Lambatach*	31 1 8·46	77 54 2·95	10474	Latitude.
Mohan	30 10 53	77 54 37	1660	Pendulum.
Mussooree, Camel's Back	30 27 35	78 4 32	6924	Pendulum.
Mussooree Dome Observatory	30 27 40·55	78 4 17·41	6937	Lat. and Azimuth.
Mussooree (Dunseverick)	30 27 28	78 3 33	7129	Pendulum.
Nag Tibba*	30 35 11·09	78 9 9·57	9915	Azimuth.
Nojli	29 53 27·76	77 40 24·59	929	Lat. and Pendulum.
Rajpur	30 23 56·83	78 6 0	3500	Latitude.
Rajpur	30 24 12	78 5 47	3321	Pendulum.
Roorkee	29 52 20	77 53 59	867	Pendulum, Standard B. M.
Sherpur	30 18 44·43	77 57 30	2916	Latitude.

* Beyond the limits of the map.

LATITUDE STATIONS.

Name of station	Geodetic Latitude			Astronomical Latitude			A—G
	°	′	″	°	′	″	″
Amsot	30	22	44·86	30	22	16·02	—28·84
Bahak*	30	45	5·22	30	44	37·60	—27·62
Bajamara*	30	45	56·20	30	45	27·79	—28·41
Banog	30	28	36·91	30	28	4·18	—32·73
Bulawāla	30	6	51·29	30	6	22·32	—28·97
Dehra Dun Base (E. End)	30	17	7·35	30	16	37·26	—30·09
Dehra Dun (Haig Observatory)	30	19	28·73	30	18	51·80	—36·93
Dehra Dun Observatory (old)	30	19	57·07	30	19	19·56	—37·51
Hatni	30	13	1·52	30	12	31·93	—29·59
Khujnaur	30	16	23·63	30	15	56·70	—26·93
Kidarkanta*	31	1	21·71	31	0	51·58	—30·13
Lachkua	30	4	34·24	30	4	5·34	—28·90
Lambatach*	31	1	8·46	31	0	34·38	—34·08
Mussooree Dome Observatory	30	27	40·55	30	27	4·02	—36·53
Nojli	29	53	27·76	29	53	14·12	—13·64
Rajpur	30	23	56·83	30	23	9·15	—47·68
Shorpur	30	13	44·43	30	13	15·30	—29·13

* Beyond the limits of the map.

AZIMUTH STATIONS.

Name of station	Station observed	Geodetic Azimuth			Observed Azimuth			A—G	(A—G) cot. Φ = Deflection in Prime Vertical
		°	′	″	°	′	″	″	″
Banog	Amsot	71	6	10·3	71	5	54·7	—15·6	E 26·5
Dehra Dun Obsy. (old)	Banog	165	11	11·8	165	10	58·5	—13·3	„ 22·7
Mussooree Dome Obsy.	Dehra Obsy. Cole's Satellite Station.	6	17	36·7	6	17	20·1	—16·6	„ 28·2
Nag Tibba*	Mussooree Eagle's Nest	32	58	55·5	32	58	41·6	—13·9	„ 23·5

* Beyond the limits of the map.

LONGITUDE STATION.

Name of station	Difference of Longitude from Kalianpur.						A — G	(A — G) cot. Φ = Deflection in Prime Vertical
	Geodetic			Electro-telegraphic				
	°	′	″	°	′	″	″	″
Dehra Dun (Haig Observatory)	0	24	4·55	0	23	38·89	—25·7	E 22·2

PENDULUM STATIONS.

Name of station	Observed g	$g\,\frac{2h}{R}$	$g\,\frac{3h}{4R}$	Orographical Correction	Value at Sea level g_o''*	γ_o†	$g_o''-\gamma_o$
Asarori	979·059	+0·231	—0·087	+0·002	979·205	979·356	—0·161
Dehra Dun . . .	979·063	+0·210	—0·079	+0·004	979·198	979·363	—0·165
Fatehpur	979·147	+0·132	—0·049	+0·003	979·233	979·371	—0·138
Hardwar	979·122	+0·089	—0·033	+0·002	979·180	979·333	—0·153
Kalsi	979·131	+0·158	—0·059	+0·011	979·241	979·378	—0·137
Mohan	979·109	+0·155	—0·058	+0·003	979·209	979·351	—0·142
Mussooree, Camel's Back .	978·793	+0·649	—0·243	+0·026	979·225	979·373	—0·148
Mussooree (Dunseverick) .	978·776	+0·668	—0·251	+0·026	579·219	979·373	—0·154
Nojli	979·143	+0·082	—0·031	+0·001	979·195	979·329	—0·134
Rajpur	979·002	+0·311	—0·117	+0·010	979·206	979·369	—0·163
Roorkee	979·129	+0·081	—0·030	+0·001	979·181	979·327	—0·146

* Reduced according to Bouguer's method assuming mean density of the earth 5·6, mean surface density 2·8.
† According to Helmert's formula of 1901, *viz.*: —

$$\gamma_o = 978{\cdot}046\ (1 + 0{\cdot}005302 \sin^2 \phi - 0{\cdot}000007 \sin^2 2\phi).$$

APPENDIX II.

LIST OF SURVEY OF INDIA PUBLICATIONS.

Publications marked * can be obtained from the Superintendent of the Trigonometrical Survey, Dehra Dūn.
" " † " " " the Officer in charge, Map Record & Issue Office, 13, Wood Street, Calcutta.
" " ‡ " " " the Officer in charge, Mathematical Instrument Office, 15, Wood Street, Calcutta.
" " ¶ " " " the Officer in charge, Surveyor General's Office, 13, Wood Street, Calcutta.
Remaining publications are either out of print or are not available for issue.

ACCOUNT OF THE OPERATIONS OF THE GREAT TRIGONOMETRICAL SURVEY OF INDIA.

Price Rupees 10-8 per volume, except where otherwise stated.

Volume I. The Standards of Measure and the Base-Lines, also an Introductory Account of the early Operations of the Survey, during the period of 1800-1830. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Survey.* Dehra Dūn, 1870 (out of print).

Do. II. History and General Description of the Principal Triangulation, and of its Reduction. *By Colonel J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1879 (out of print).

Do. III. The Principal Triangulation, the Base-Line Figures, the Karāchi Longitudinal, N. W. Himālaya, and the Great Indus Series of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Trigonometrical Survey, and his Assistants.* Dehra Dūn, 1873 (out of print).

Do. IV. The Principal Triangulation, the Great Arc—Section 24°—30°, Rahūn, Gurhāgarh and Jogī-Tīla Meridional Series and the Sutlej Series of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Trigonometrical Survey, and his Assistants.* Dehra Dūn, 1876.*

Do. IVA. General Description of the Principal Triangulation of the Jodhpore and the Eastern Sind Meridional Series of the North-West Quadrilateral, with the Details of their Reduction and the Final Results. *Prepared in the Office of the Trigonometrical Branch, Survey of India, Colonel C. T. Haig, R.E., Officiating Deputy Surveyor-General in charge, and published under the orders of Colonel G. C. DePrée, S.C., Surveyor-General of India.* Dehra Dūn, 1886.*

Do. V. Details of the Pendulum Operations by Captains J. P. Basevi, R. E., and W. J. Heaviside, R.E., and of their Reduction. *Prepared under the directions of Major-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn and Calcutta, 1879.*

Do. VI. The Principal Triangulation of the South-East Quadrilateral, including the Great Arc—Section 18° to 24° the East Coast Series, the Calcutta and the Bider Longitudinal Series, the Jabalpur and the Bilāspur Meridional Series, and the details of their Simultaneous Reduction. *Prepared under the directions of Major-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn, 1880 (out of print).

Do. VII. General Description of the Principal Triangulation of the North-East Quadrilateral, including the Simultaneous Reduction and the Details of five of the component Series, the North-East Longitudinal, the Budhon Meridional, the Rangir Meridional, the Amua Meridional, and the Karāra Meridional. *Prepared under the directions of Lieutenant-General J. T. Walker, C.B., R. E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn, 1882.*

Do. VIII. Details of the Principal Triangulation of eleven of the component Series of the North-East Quadrilateral, including the following Series; the Gurwāni Meridional, the Gora Meridional, the Hurilāong Meridional, the Chendwār Meridional, North Parāsnāth Meridional, the North Malūncha Meridional, the Calcutta Meridional, the East Calcutta Longitudinal, the Brahmapūtra Meridional, the Eastern Frontier—Section 23° to 26°, and the Assam Longitudinal. *Prepared under the directions of Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn, 1882.*

Do. IX. Electro-Telegraphic Longitude Operations executed during the years 1875-77 and 1880-81, by Lieutenant-Colonel W. M. Campbell, R. E., and Major W. J. Heaviside, R.E. *Prepared under the directions of Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Trigonometrical Survey.* Dehra Dūn, 1883.*

Do. X. Electro-Telegraphic Longitude Operations executed during the years 1881-82, 1882-83, and 1883-84, by Major G. Strahan, R. E., and Major W. J. Heaviside, R. E. *Prepared under the directions of Colonel C. T. Haig, R. E., Deputy Surveyor-General, Trigonometrical Branch, and published under the orders of Colonel H. R. Thuillier, R. E., Surveyor-General of India.* Dehra Dūn, 1887.*

Do. XI. Astronomical Observations for Latitude made during the period 1805 to 1885, with a General Description of the Operations and Final Results. *Prepared under the directions of Lieutenant-Colonel G. Strahan, R. E., Deputy Surveyor General, Trigonometrical Branch, and published under the orders of Colonel H. R. Thuillier, R.E., Surveyor-General of India.* Dehra Dūn, 1890.*

Do. XII. General Description of the Principal Triangulation of the Southern Trigon, including the Simultaneous Reduction and the Details of two of the component Series, the Great Arc Meridional—Section 8° to 18°, and the Bombay Longitudinal. *Prepared under the directions of Lieutenant-Colonel G. Strahan, R. E., Deputy Surveyor-General, Trigonometrical Branch, and published under the orders of Colonel H. R. Thuillier, R.E., Surveyor-General of India.* Dehra Dūn, 1890.*

Do. XIII. Details of the Principal Triangulation of five of the component Series of the Southern Trigon, including the following series; the South Konkan Coast, the Mangalore Meridional, the Madras Meridional and Coast, the South-East Coast, and the Madras Longitudinal. *Prepared under the directions of Lieutenant-Colonel G. Strahan, R. E., Deputy Surveyor-General, Trigonometrical Branch, and published under the orders of Colonel H. R. Thuillier, R. E., Surveyor General of India.* Dehra Dūn, 1890.*

Volume XIV. General Description of the Principal Triangulation of the South-West Quadrilateral, including the Simultaneous Reduction and the Details of its component Series. *Prepared under the directions of W. H. Cole, Esq., M. A., Officiating Deputy Surveyor-General, Trigonometrical Branch, and published under the orders of Colonel H. R. Thuillier, R. E., Surveyor General of India.* Dehra Dūn, 1890.*

Do. XV. Electro-Telegraphic Longitude Operations executed during the years 1885-86, 1887-88, 1889-90 and 1891-92, and the Revised Results of Arcs contained in Volumes IX and X; also the Simultaneous Reduction and the Final Results of the whole of the Operations. *Prepared under the directions of Colonel G. Strahan, R.E., Deputy Surveyor-General, Trigonometrical Branch, and published under the orders of Colonel H. R. Thuillier, R.E., Surveyor-General of India.* Dehra Dūn, 1893.*

Do. XVI. Details of the Tidal Observations taken during the period from 1873 to 1892 and a Description of the Methods of Reduction. *Prepared under the directions of Major S. G. Burrard, R.E., Superintendent, Trigonometrical Surveys, and published under the orders of Colonel St. G. C. Gore, R.E., Surveyor-General of India.* Dehra Dūn, 1901.*

Do. XVII. Electro-Telegraphic Longitude Operations executed during the years 1894-95-96. The Indo-European Arcs from Karāchi to Greenwich. *Prepared under the directions of Major S. G. Burrard, R.E., Superintendent, Trigonometrical Surveys, and published under the orders of Colonel St. G. C. Gore, R.E., Surveyor-General of India.* Dehra Dūn, 1901.*

Do. XVIII. Astronomical Observations for Latitude made during the period 1885 to 1905 and the Deduced Values of the Deflections of the Plumb-line. *Prepared under the directions of Lieutenant-Colonel S. G. Burrard, R.E., F.R.S., Superintendent, Trigonometrical Surveys, and published under the orders of Colonel F. B. Longe, R.E., Surveyor-General of India.* Dehra Dūn, 1906.*

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SYNOPSES OF THE RESULTS OF THE OPERATIONS OF THE GREAT TRIGONOMETRICAL SURVEY OF INDIA, COMPRISING DESCRIPTIONS, CO-ORDINATES, ETC., OF THE PRINCIPAL AND SECONDARY STATIONS AND OTHER FIXED POINTS OF THE SEVERAL SERIES OF TRIANGLES.

Price Rupees 2 per volume, except where otherwise stated.

Volume I. The Great Indus Series, or Series *D* of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Trigonometrical Survey, and his Assistants.* Dehra Dūn, 1874.*

Do. II. The Great Arc—Section 24° to 30°, or Series A of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1874.*

Do. III. The Karāchi Longitudinal Series, or Series *B* of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1874.*

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Do. V. The Rahūn Meridional Series, or Series *E* of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1875.*

Do. VI. The Jogi-Tīla Meridional Series, or Series *G*, and the Sutlej Series, or Series *H* of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1875.*

Do VII. The North-West Himālaya Series, or Series *C* of the North-West Quadrilateral, and the Triangulation of the Kashmīr Survey. *By Major-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Survey and his Assistants.* Dehra Dūn, 1879. (This volume is of great use to mountaineers.)*

Do. VIIA. The Jodhpore Meridional Series and the Eastern Sind Meridional Series of the North-West Quadrilateral. *Prepared in the Office of the Trigonometrical Branch, Survey of India, Colonel C. T. Haig, R.E., Deputy Surveyor-General, in charge, and published under the orders of Colonel H. R. Thuillier, R.E., Surveyor-General of India.* Dehra Dūn, 1887.*

Do. VIII. The Great Arc—Section 18° to 24°, or Series *A* of the South-East Quadrilateral. *By Colonel J. T. Walker, C.B., R.E., F.R.S., etc., etc., Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1878.*

Do. IX. The Jabalpur Meridional Series, or Series *E* of the South-East Quadrilateral. *By Colonel J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Survey and his Assistants.* Dehra Dūn, 1878.*

Do. X. The Bider Longitudinal Series, or Series *D* of the South-East Quadrilateral. *By Major-General J. T. Walker, C. B., R. E., F. R. S., etc., etc., Surveyor-General of India and Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1880.*

Do. XI. The Bilāspur Meridional Series, or Series *F* of the South-East Quadrilateral. *By Major-General J. T. Walker, C. B., R. E., F. R. S., etc., etc., Surveyor-General of India and Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1880.*

Do. XII. The Calcutta Longitudinal Series, or Series *B* of the South-East Quadrilateral. *By Major-General J. T. Walker, C. B., R. E., F. R. S., etc., etc., Surveyor-General of India and Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1880.*

Do. XIII. The East Coast Series, or Series *C* of the South-East Quadrilateral. *By Major-General J. T. Walker, C. B., R. E., F. R. S., etc., etc., Surveyor-General of India and Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1880.*

Volume XIIIA. The South Parāsnāth Meridional Series and the South Malūncha Meridional Series of the South-East Quadrilateral. *Prepared in the Office of the Trigonometrical Branch, Survey of India, Colonel C. T. Haig, R. E., Officiating Deputy Surveyor-General, in charge, and published under the orders of Colonel G. C. DePrée, S. C., Surveyor-General of India.* Dehra Dūn, 1885.*

Do. XIV. The Budhon Meridional Series, or Series *J* of the North-East Quadrilateral. *By Lieutenant-General J. T. Walker, C. B., R. E., F. R. S., etc., etc.. Surveyor-General of India and Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1883.*

Do. XV. The Rangir Meridional Series, or Series *K* of the North-East Quadrilateral. *By Lieutenant-General J. T. Walker, C. B., R. E., F. R. S., etc., etc., Surveyor-General of India and Superintendent of Survey, and his Assistants.* Dehra Dūn, 1883.*

Do. XVI. The Amua Meridional Series, or Series *L*, and the Karāra Meridional Series, or Series *M* of the North-East Quadrilateral. *By Lieutenant-General J. T. Walker, C. B., R. E., F. R. S., etc., etc., Surveyor-General of India, and Superintendent of the Survey, and his Assistants.* Dehra Dūn, 1883.*

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(*c*) A Manual of Surveying for India, detailing the mode of operations on the Trigonometrical, Topographical and Revenue Surveys of India. *Compiled by Colonel H. L. Thuillier, C.S.I., F.R.S., F.R.A.S., F.R.G.S., etc., Royal Artillery, and Lieutenant-Colonel R. Smyth, late Bengal Artillery. Prepared for the use of the Survey Department of India, and published under the Authority of the Government of India.* Third Edition, revised and enlarged. Calcutta, 1875.

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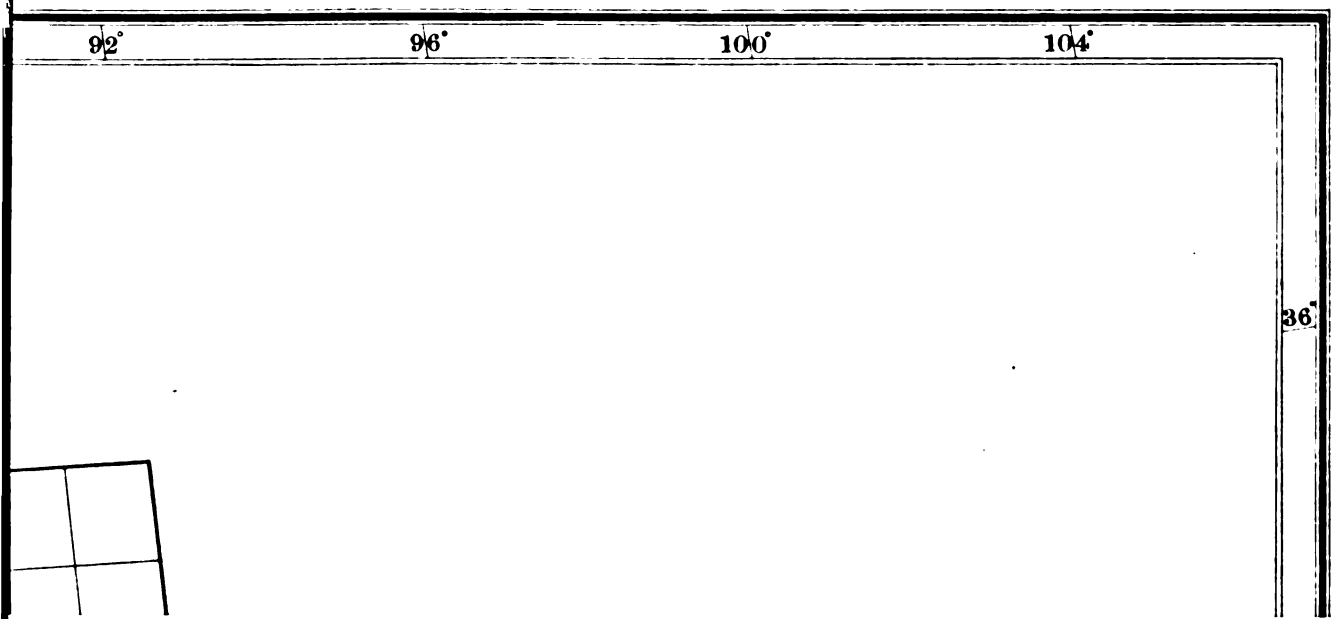

9